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ASTM Bulletin

NEWS—Annual Meeting, Program and Exhibit, Technical Committees, District Activities.

PAPERS—Plastics, Chemical Analysis, Consumer Goods Testing, Grease, Fuel Oils, Materials Engineering.

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ASTM BULLETIN

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TESTING MATERIALS

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MAY—1946

No. 140

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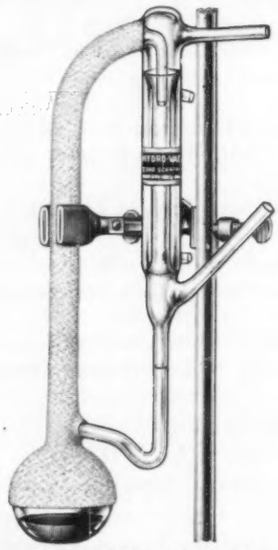

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SPRINGFIELD, PA.

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—RITtenhouse 5315

R. E. Hess, Editor
R. J. Painter, Associate Editor

CABLE ADDRESS—TESTING

Number 140 May 1946

Record-Breaking Annual Meeting in Prospect

Largest Attendance Expected With 24 Outstanding Technical Sessions, Apparatus Exhibit, and over 200 Committee Meetings

THERE is in store for the members and committee members in Buffalo during the week of June 24 one of the most interesting Annual Meetings that will have been held by the Society. With the great expansion in A.S.T.M. technical activities resulting in an outstanding technical program, and in addition two exhibits, and probably the largest number of technical committee meetings yet held, the highest attendance of any meeting is anticipated. This BULLETIN, with the Provisional Program (see pages 96 to 106) which includes synopses of most of the technical papers to be presented and a list of the committee reports, presents although perhaps none too adequately, an advance picture of the many activities. Information on the Exhibit, which includes notes on what some of the exhibitors will highlight, and other news material, including the Edgar Marburg Lecture, the dinner being sponsored by the Buffalo Committee on Arrangements, and other items, is also given.

The A.S.T.M. headquarters hotel is The Statler in which all of the technical sessions will be held, the two exhibits (one on apparatus and the other photographic), and most if not all of the technical committee meetings. The meeting registration desk will be in the Ballroom Foyer which is on the Lobby Floor close to the hotel desks. Session rooms are on the Lobby, Mezzanine, and Seventeenth Floors, the latter also the location for the Seventh Exhibit of Testing Apparatus and Related Equipment and the Photographic Exhibit.

Technical Program

In order to provide adequate time for the presentation of what are most certainly some of the most interesting technical papers yet scheduled for any meetings, twenty-four separate sessions have been arranged. It will be noted that Tuesday, Wednesday, and Thursday are particularly active days from the standpoint of technical symposiums and groups of papers. Monday morning and afternoon have been left clear for committee meetings, but as the case with every annual meeting there will be committees meeting throughout the whole week.

Symposium on Bearings:

This symposium will give an authoritative discussion on the testing of various types of bearings—plain, ball and roller anti-friction, airplane bearings, etc. Mr. E. W. Upham, Chrysler Corp., has been responsible for planning this event, the subjects for which originated in discussions by the A.S.T.M. Administrative

The Society Moves

ON May 27 the Society will occupy its new headquarters at 1916 Race St., Philadelphia—or more exactly, such portion of the building as has so far been finished.

Delays due to strikes and materials shortages have seriously slowed up alterations and new construction and we are several months behind schedule. It accordingly became necessary to concentrate work on the center and rear portions of the building, comprising the general offices, publication and shipping rooms, so that the Staff could move in this month. These portions of the building, containing about two thirds of the floor area, are now substantially completed and can be used without much impairment of efficiency of operation pending final completion.

The front part of the building, which includes the main entrance and lobby, Members' Room, Board and Committee Rooms and Secretary's office, will not be finished for several months. It is the earnest hope of the Executive Committee that the entire building will be substantially completed in time for a formal opening and "house-warming" in early October.

After May 27: **Address: 1916 Race Street, Philadelphia 3, Pa.**
Telephone: RITtenhouse 5315

Committee on Simulated Service Testing.

Symposium on Fatigue of Materials:

The purpose of this symposium is to provide an over-all picture of work on fatigue, not only of metals, but nonmetals as well, although most of the papers do deal with the subject from the metals viewpoint. Magnesium, beryllium copper, aluminum, and copper alloys of various kinds are to be covered; also steel, and an interesting paper on the fatigue strength of wood.

Symposium on Testing of Parts and Assemblies:

This subject, somewhat related to the one on fatigue, is sponsored jointly with the Society for Experimental Stress Analysis which is having its meeting in Buffalo, June 24. The S.E.S.A. cooperated in developing the two sessions on the morning and afternoon of June 26. Topics to be covered include aircraft studs and bolts; automotive axles, propeller bronzes, and such topics as testing of aircraft structures, relation between stress concentration and fatigue, and others.

Oil Procurement Practices:

The objective here is to provide a compendium of the various thoughts and practices in connection with the procurement of lubricants and the two sessions, morning and afternoon of Wednesday, June 26, have been arranged by Committee D-2's Technical Committee B on Lubricating Oils.

There will be contributions depicting the practice and experience of various producing companies and those who are large purchasers of oils and lubricants including the U. S. Navy, General Electric Co., and American Airlines. This symposium is related to intensive consideration in Committee D-2 of the desirability of establishing purchase specifications for lubricants and the contributions in Buffalo will aid the committee in its desire to take appropriate steps in the best interests of all concerned.

Symposium on Effect of Temperature on the Properties of Metals:

There are two sessions involved here, one dealing with materials for gas turbines, where a number of authorities will speak who have played important parts in solving the very perplexing problems to make suitable materials available for turbines. The following session, the night of June 27, is a general one, with papers covering graphitization of various types of steel, and other problems of concern particularly to those who are designing and fabricating turbines, pressure piping and the like.

Symposium on pH Measurement:

The importance of pH measurement in so many fields of activity led Technical Committee XIII on Hydrogen Ion Determinations which functions under the general A.S.T.M. Committee E-1 on Methods of Testing, to arrange this extensive symposium which will be in two sessions on Thursday. The objective has been to provide a rather complete coverage starting from historical discussion of pH and pH measurements through the whole gamut of theory, corrections, various applications, and instruments.

Symposium on Atmospheric Resistance of Stainless Steels:

Under the sponsorship of Committee A-10 on Iron-Chromium and Iron-Chromium-Nickel Alloys, this symposium covering various types of corrosion-resistant or so-called "stainless" steels is intended to provide an authoritative discussion of the great amount of research work that has been carried on and a reasonable interpretation by various authorities of the service value of the chromium-nickel materials.

Symposium on Freezing and Thawing Tests:

The objective in this symposium on Thursday evening, June 27, is to provide an evaluation of the various test methods used to determine the effects of freezing and thawing on concrete—in short, to have a constructive discussion on the durability of this material.

Other Sessions and General Committee Report Sessions:

It will be noted from the Provisional Program that the last three sessions of the meeting on Friday afternoon, June 28, are devoted to the technical papers on plastics, wood, and non-ferrous metals, and on bituminous materials.

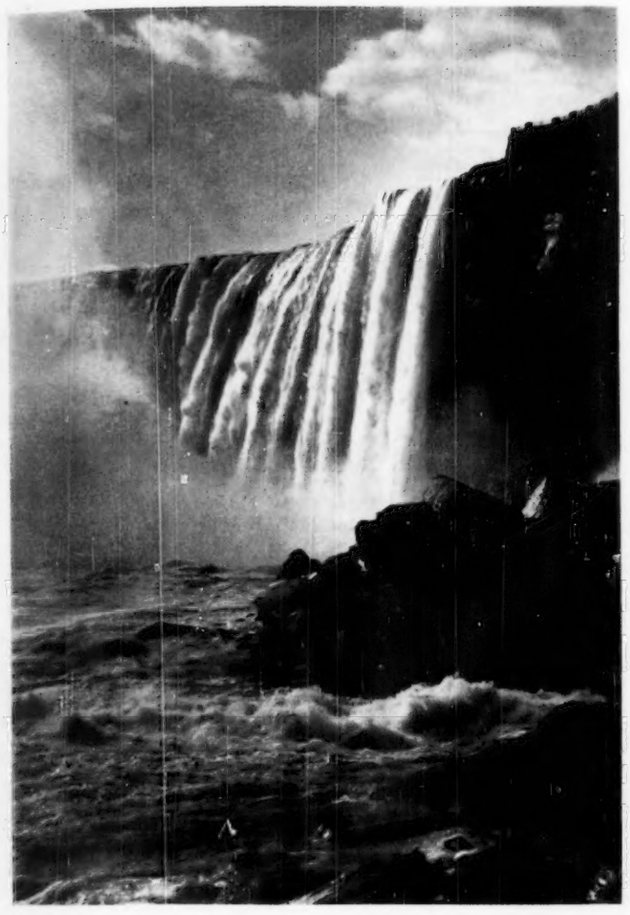
As indicated in previous communications to the members there are several sessions at the meeting this year which will be devoted entirely to the presentation of the reports of various technical committees, thus concentrating this important part of the meeting. At these sessions the committees will submit the annual reports with the expected unusually large number of recommendations on new and revised standards. This leaves the other sessions practically clear for papers and symposiums and concentrates much of the activity on standards.

Edgar Marburg Lecture; President's Address and Dinner Session

On the following pages are notes on the Society's Twentieth Edgar Marburg Lecture to be presented on Wednesday, June 26, at 4:15 o'clock by Dr. Joseph J. Mattiello, Vice-President and Technical Director, Hilo Varnish Corp., one of the outstanding authorities in his chosen field. His subject is to be "Protective Coatings as Engineering Materials." Dr. Mattiello has been devoting much time to the preparation of his lecture and while at the meeting it will necessarily be presented somewhat in abbreviated form, nevertheless, a capacity audience is expected.

Another event which members will find of outstanding interest is the dinner on the night of Wednesday June 26, which is being arranged by the Program Committee of the Buffalo Committee on Arrangements. At this dinner the retiring president, John R. Townsend, Bell Telephone Laboratories, will give his President's Address which this year will embody conclusions from his extensive experience as Materials Standards Engineer and Materials Engineer with the Bell Laboratories and his extensive work during both peace and war on a wide variety of important technical problems.

Joining the President, as guest speaker at the dinner, will be Dr. Bernard Keble Sandwell, Managing Editor of *Saturday Night*—one of Canada's most widely read weekly news periodicals. A gifted public



Over these Falls at Niagara tumble a reputed 1½ million gallons of water a second, on the way from Lakes Superior, Michigan, Huron, and Erie to Lake Ontario and the sea.

speaker with an intriguing sense of humor, Dr. Sandwell will unquestionably find a very cordial welcome in Buffalo. Some notes of a biographical nature appear later in this BULLETIN. A most interesting article entitled "The Good Humored Oracle" was written about Dr. Sandwell in the April 1 issue of *Maclain's Magazine*. This feature of the meeting promises to be most interesting and entertaining as well as thought-provoking.

Committee Meetings

Even before the war but noticeably during the A.S.T.M. meetings held from 1941 through 1944 there seemed to be an unusually large number of technical committee meetings, but it is evident from advance returns from the technical committees that there will be more groups convening in Buffalo beginning Monday, June 24, and extending through Friday, than for any previous A.S.T.M. meetings. Obviously as the Society's work expands into newer fields there will be an increasing number of new technical committees and since to keep up to date the large number of specifications and continually carry on necessary research work it is essential to keep the older groups standing, the number of committees is bound to be on the upgrade, with many more meetings whenever there is a large A.S.T.M. meeting.

Schedules:

Unlike the practice for the Spring Meeting, when an attempt is made to distribute in advance to each member of the Society a schedule of committee meetings, the practice for the Annual Meeting because of the complexity of various factors involved is to have each committee notify its own members of the meeting. However, in Buffalo there will be furnished to each member and committee member as he registers a complete final program giving lists of all committees meeting, room assignments, etc., as well as the technical session programs, apparatus exhibit directory, etc.

Preprints of Reports and Papers

Each member in good standing received earlier in May a Preprint Request Blank which he could mark and return to A.S.T.M. Headquarters, thus making known his desire to have certain papers or reports that would be preprinted. This material will be mailed probably in three installments, the final one probably just before the Annual Meeting. Members attending the meeting can of course obtain as they register, copies of preprinted papers and reports, or abstracts of items that it was not possible to preprint and other such material.

Buffalo Committee on Arrangements

The success of an A.S.T.M. Annual Meeting always has depended upon the various groups cooperating in planning the technical program, committee meetings, and other features of the meeting including what are termed "entertainment features." This situation is emphasized as the A.S.T.M. activities expand and its meetings become more complex. When the Annual Meeting is held in an industrial center, the Society officers lean heavily on the Local Committee on Arrangements, and this year the group in Buffalo and its environs have assisted greatly in a number of activities and with respect to some noted below is taking full responsibility. As mentioned in the March BULLETIN the Western New York-Ontario District members comprise the basic personnel for the committee on arrangements, but a number of other members in Buffalo are serving. B. L. McCarthy, Wickwire Spencer Division, who is the District Chairman, has been very seriously ill and is now convalescing, so that T. L. Mayer, Buffalo Public Library, District Secretary, is directing and correlating the local activities as Acting Chairman. The complete personnel of the local

committee follows, together with the lists of the various subcommittees and their personnel.

General Committee on Arrangements

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T. L. Mayer, *Vice-Chairman, and Acting Chairman*, Buffalo Public Library
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T. H. Adair, Atlas Steels, Ltd.
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R. F. Cameron, Wickwire Spencer Steel Division
J. Gentile, Pittsburgh Testing Laboratory
C. M. Little, American Brass Co.

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H. E. Seeman, Eastman Kodak Co.
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Mrs. O. W. Ellis
Mrs. C. W. Georgi
Mrs. F. L. Koethen
Mrs. W. H. Lutz
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About Buffalo

The 14th city in population in the United States, Buffalo is rated 9th as far as industrial activity is concerned. Because of its strategic location Buffalo is the greatest export and import point in trade with Canada. It is rated as the second largest railroad center and it is the first city in the world in flour and feed milling, with about 60 million bushels of wheat processed annually. Of this about 70 per cent has gone into flour.

According to information from the Chamber of Commerce the following railroads operate into Buffalo: New York Central, Pennsylvania, Erie, D. L. & W., Lehigh Valley, Baltimore & Ohio, Canadian National (Grand Trunk), Michigan Central, Wabash, Nickel Plate, Pere Marquette, and Canadian Pacific.

Among the interesting points to visit from Buffalo would be the following: Niagara Falls, the Chautauqua Assembly, Allegany State Park, the historic Old Fort Niagara, Letchworth Park, and Watkins Glen.

The city has several outstanding high schools, and its institutions of higher learning include the University of Buffalo, Canisius College, D'youville College, and State Teachers College.

Among the interesting buildings to visit would be the Buffalo Historical Society Museum and the Albright Art Gallery, the latter with a well-established international reputation in art circles.

With the unfailing source of cheap hydroelectric power the Buffalo area is probably the world's largest electrochemical and electrometallurgical center. Reference might be made to a number of other very significant factors about Buffalo and the surrounding area including its strategic setting as the terminus of the New York State Barge Canal and the connection with the Great Lakes. Huge tonnages of grain, iron ore, coal, and limestone clear through the city.

Map of the Niagara River from Lake Erie to Lake Ontario

Dr. J. J. Mattiello Will Deliver 1946 Edgar Marburg Lecture

Outstanding Authority to Discuss Protective Organic Coatings as Engineering Materials

J. J. Mattiello

THE selection of Dr. J. J. Mattiello, Vice-President and Technical Director, Hilo Varnish Corp., Brooklyn, N. Y., to deliver the 1946 Edgar Marburg Lecture at the Society's Annual Meeting in Buffalo, the lecture being scheduled for late Wednesday afternoon, June 26, brings to the Annual Meeting Program one of the outstanding authorities, nationally and internationally, in his chosen field of protective coatings. Dr. Mattiello has selected as the subject of his lecture "Protective Organic Coatings as Engineering Materials" and the short synopsis appearing below indicates to some extent the significance of this subject. A problem engaging the efforts of thousands of scientists and large numbers of others concerned with the production and application of the various materials, the whole subject of protective coatings was of paramount importance during wartime and with the return of peace is consequently a very timely one.

As indicated by the biographical material which follows, Dr. Mattiello has been extremely active in a wide variety of technical and professional work. In A.S.T.M., of which he has been a member for many years representing his company (since 1934) he is an active member of Committee D-1 on Paint, Varnish, Lacquer and Related Products, and Committee D-17 on Naval Stores.

The Marburg Lecture, first established in 1925, has each year until 1945 when the event was postponed because of wartime restriction on meetings, brought to the Annual Meeting leaders in their respective fields. These men described in lectures which when subsequently published have been heralded as major contributions to technical literature, outstanding developments in our knowledge of engineering materials. The lecture commemorates the name of the Society's first Secretary who, through his development of technical programs and in other ways, brought wide recognition to A.S.T.M. as a forum for the discussion of tests and properties of materials.

The 1946 lecture, to be held in the Assembly Room on the 17th floor of the Hotel Statler in Buffalo, June 26, will start at 4:15 p.m., Buffalo time.

Synopsis of 1946 Marburg Lecture

Protective Organic Coatings as Engineering Materials

THE manufacture of protective organic coatings is becoming an industrial science. The term "Organic Coatings" in its present meaning includes such materials as varnishes, paints, enamels, lacquers, clear and pigmented textile coatings, plastics, and similar special coating materials.

Organic coatings serve man in a wide variety of engineering and nonengineering fields such as agricultural equipment, domestic appliances, food containers, industrial plants, insulation, transportation, the interior and exterior of homes, etc.

The main function of protective coatings in relation to metal surfaces is to retard corrosion and thereby prolong the life and improve the efficiency of engineering materials.

The growth of the organic coating industry, like that of other industries, has been primarily a development of the arts. While empirical methods still play a significant part in the development of new coatings, the industry's progress is guided mainly by the application of fundamental physical and chemical principles.

The impetus due to the war effort has given the chemists and the chemical engineers and the other technically trained men of the industry their first real opportunity to emphasize the chemical and engineering aspects of the protective coating industry.

The initial physical and chemical properties of the chemical raw materials are the first means of controlling the properties of the final dry coated films and their life or durability. Only a relatively few natural products were employed in the industry in the early part of the 20th century. Through the application of chemical knowledge man has changed the chemical properties of some natural products and has chemically synthesized many raw materials with specific properties for specific end uses in protective coatings.

While technical knowledge will permit the chemist to develop organic coatings with increased film strengths, flexibility, hardness and toughness, improved chemical resistance, vapor impermeability, and improved general durability,—the preparation of the surfaces prior to the application of coatings is equally as important as the designing of organic coatings for specific uses.

The adoption of many new analytical test methods has presented the industry with new subjects and ideas which are broadening the horizon and supplying new instrumentations and techniques which are establishing the art still more firmly as a chemical engineering industry.

In the future the industry will certainly be confronted with many new chemically synthesized film-forming materials, some of which are in the offing, others probably not even on the horizon at the present time.

About the Lecturer, Dr. Mattiello

IF 1900 had been a leap year, Joseph Mattiello would still have missed the distinction of being one of those who has a birthday every four years since he was born on February 28, 1900, in New York City. He attended public and private schools there and the Polytechnic Institute of Brooklyn, where he received his B.S. degree in 1925, and his Master's in 1931. Columbia University awarded him the degree of Ph.D. in 1936.

From June to October, 1916, he went to the Mexican border as a member of Company "I," 14th Infantry, New York National Guard and in October, 1917, at the

age of seventeen, he went to France with the American Expeditionary Forces. He was a Sergeant of Company H, 165th U. S. Infantry (Old 69th N.Y.N.G.), 42nd Rainbow Division. He served in the defensive sectors of Luniville and Baccarat, and participated in the battles of Champagne-Marne, Aisne-Marne (Chateau-Thierry Sector), St. Mihiel, and Meuse-Argonne. He was seriously wounded in the right arm and in both legs on October 17, 1918, in the Meuse-Argonne, which resulted in the loss of his right leg. He received Regimental Citation and the Order of the Purple Heart.

Since his graduation from the Polytechnic Institute, he has been associated with the Hilo Varnish Corporation of which he is Vice-President and Technical Director, and a member of the Board of Directors.

Dr. Mattiello has conducted extensive fundamental investigations in bodied drying oils and many related protective coating problems. During the war period he concentrated all his efforts on protective coating problems directly associated with the war effort. Beginning in July, 1942, in addition to his many other duties he devoted the greater part of his energies to the Quartermaster Corps as a consultant on protective coatings to the Plastics Section, Research and Development Branch, Military Planning Div. During this time, he was active director of all research and development on the paints, varnish and lacquer used on QMC equipment.

He received from the War Department, Army Service Forces, the Meritorious Civilian Service Award, for his valuable contributions in the war effort. The citation of his award reads:

"For outstanding services in solving the protective coating problems confronting the Quartermaster Corps. With exceptional resourcefulness and ingenuity he assisted the Quartermaster General in developing satisfactory organic coatings and methods of application to quartermaster items, with particular emphasis on the procoating program."

He is also Adjunct Professor in the Department of Chemical Engineering of the Polytechnic Institute of Brooklyn.

One of his outstanding technical activities has been as Editor of *Protective & Decorative Coatings*, five volumes, etc. (1941–1945), published by John Wiley & Sons. He is author and co-author of numerous other publications on subjects dealing with bodied oils, paints, varnishes, printing inks, etc., and edited a book, *Protective & Decorative Coatings* issued by the Office of The Quartermaster General, March, 1945.

He is a member of the professional honorary societies—Delta Kappa Pi, Phi Lambda Upsilon, and Sigma Xi.

Dr. Mattiello has been very active in the work of technical and professional organizations including the Federation of Paint and Varnish Production Clubs, American Chemical Society, The American Institute of Chemical Engineers, American Institute of Chemists, Oil & Colour Chemists Association, Society of Chemical Industry, American Society for Testing Materials and others. He has been particularly active in the work of A.S.T.M. Committee D-1 and its subcommittees, and serves also on Committee D-17 on Naval Stores.

His activities have been very extensive in the Federation of Paint and Varnish Production Clubs which consists of 22 clubs—19 in the United States, 2 in Canada, and 1 in Birmingham, England. He has been chairman of many of its committees and was president for the year 1944. This latter organization has contributed much technical effort to the prosecution of the war.

He married Josephine Critelli in 1922 and they have four daughters—Margaret Ann, Elizabeth, Rosamond, and Barbara.

In addition to being something of a philatelist, he is a collector of books.

About the Guest Speaker—Bernard Keble Sandwell

REPORTS from our Canadian members who have had the pleasure of hearing Dr. B. K. Sandwell indicate that he is a most interesting speaker, and a review of his background and activities would of themselves seem to indicate his standing. Currently editor of the widely distributed Canadian publication *Saturday Night* where he has served since 1932, he has a wide reputation not only as an editor but as a speaker and educator. Born in Ipswich, England, the son of a Congregationalist minister, he came to Canada in 1888 at the age of 12. Educated at Upper Canada College and the University of Toronto (his B.A. degree was in 1897), he served on the editorial staffs of different Canadian newspapers, was a free-lance writer, and for seven years until 1918 was editor of the Montreal *Financial Times*. He was then for several years on the Faculty of the School of Economics at McGill University, and has been a Member of the Staff of the Alexander Hamilton Institute of New York.

Dr. Sandwell is a Fellow of the Royal Society of Canada and was awarded his LL.D. degree from Queens in 1942. He has been a prolific writer.

The widely distributed Canadian publication *Maclean's*, termed "Canada's National Magazine," in its April 1 issue had a most interesting article about Dr. Sandwell entitled "Good-Humored Oracle" prepared by Thelma LeCocq. The author points out that Dr. Sandwell all his life has gone in for being a novelty. Some of his interesting statements quoted in the article follow: "My qualification for editing a paper in Toronto," Sandwell explains, "is that I've lived for so many years in Montreal." At one time he introduced a Toronto audience to a visiting lecturer by saying, "You see before you a fairly complete cross-section of the intelligentsia of Toronto. I hope you are not too depressed." A constant good humor, which all who know him appreciate to the full, characterizes his whole life.

Dr. B. K. Sandwell

Seventh Exhibit of Testing Apparatus and Related Equipment to be a Meeting Feature

Leading Companies in the Apparatus and Laboratory Supply Fields Participating; Technical Committees and Others to Sponsor Research Displays

THE Seventh Exhibit of Testing Apparatus and Related Equipment, this feature of the Annual Meeting being renewed after a gap of four years, will provide the thousands of A.S.T.M. members, committee members, and visitors an unexcelled opportunity to see under favorable circumstances many of the notable apparatus developments that have taken place in the war years. From the list of apparatus and related companies participating in the commercial section of the Exhibit, and the advance descriptions of their displays which are given below, it will be seen that a very wide variety of instruments, machines, testing supplies, laboratory equipment, and related items of all kinds will be shown in the Exhibit.

A cordial invitation is extended to all who are interested in the instruments and related fields to attend the Exhibit. In the past the exhibits have attracted an attendance of large numbers of technical men, production executives, and others concerned with materials from all parts of the United States and Canada, many of whom might not otherwise have been attending the Annual Meeting. Holding the Exhibit during the Society's Annual Meeting when there is concentration on standardization and research work in materials provides those concerned, with a fine opportunity to observe latest developments in the diverse materials fields, and to evaluate the various results of the instrument companies' efforts to make available for testing engineers, research men and others, adequate equipment to evaluate materials products, and processes.

Committee and Research Exhibits

The policy of inviting A.S.T.M. technical committees to sponsor booth displays which would feature some phases of their technical activities where the development and use of specifications and tests are involved, has been followed for the 1946 Exhibit and there will be several interesting committee displays. Committee A-3 on Cast Iron in its display will show a number of novel methods of testing cast iron with various types of impact, fatigue, torsion, damping capacity, and other types of specimens.

Committee B-1 on Wires for Electrical Conductors will show an interesting fine wire winding stand which expedites testing, and the group concerned with corrosion of non-ferrous metals and alloys, B-3, will have numerous panels and other display covering their work on atmospheric galvanic and electrolytic corrosion tests, the specimens having been removed from the various test sites. These corrosion displays have always created much interest.

Perhaps the most extensive committee display will be under the auspices of Technical Committee G on Grease, functioning under Committee D-2 on Petroleum Products and Lubricants. This group through the cooperation of companies participating in the commercial section of the Exhibit will show diverse instruments and apparatus that have been developed to evaluate the various properties of grease—penetrometers, grease workers, dropping point, evaporation, oxidation, bearing testers, etc.

Committee D-7 on Wood is planning an interesting display based on the various specifications and tests it has developed, with information about the numerous classes and grades of woods, the effect of agencies which destroy wood, such as fungi, marine borers, termites and the like, and some of the advantages of preservative treatments. Some testing equipment used to evaluate wood may be in this display.

Educational Exhibits

The Committee on the Apparatus Exhibit, the personnel of which is given elsewhere in this BULLETIN, has arranged for displays by organizations in Buffalo whose activities tie in with work in the field of materials. The Buffalo Technical High School, a leading one in the state, will sponsor a display showing how the high school student is acquainted with the importance of evaluating materials and products. The Buffalo Technical Library will stress the bibliographic phases of research and testing and the new Cornell Aeronautical Laboratory which during the time of the A.S.T.M. Meeting and Exhibit, June 26, is having its dedication program, will have a unique display on work it is fostering. The National Gypsum Co. has some interesting equipment for evaluating building materials and this will be shown.

There will be an A.S.T.M. booth in the Exhibit giving information about the Society and there will be material available for distribution to the visitors, information on publications, technical committee activities, and the like. This booth can be used as a convenient meeting place for anyone who wishes to meet some friend or associate.

The Exhibit will be held on the Statler's Seventeenth Floor and some committee meetings and sessions will be held in the excellent meeting room on this floor.

The exhibitors have been urged to stress technical and educational matters in their booth displays and each of them will have capable representatives, in many cases executives of the companies, on hand to discuss problems with those attending the Exhibit.

(Please turn page for booth descriptions)

BURRELL

Upper Left: High-Temperature Fatigue Machine; Upper Center: Gas Analysis Unit; Upper Right: A Small Capacity X-ray Unit, Low Voltage; Center Left: Tukon Hardness Tester; Center: Interferograph; Center Right: Another Accelerated Weathering Unit; Lower Left: Supersonic Reflectoscope; Center: New Impact Machine; Lower Right Top: Launder-Ometer; Lower Right: Dynamometer Strain Gage.

ACME INDUSTRIAL CO.

Booth 28

This exhibit will show to the A.S.T.M. members and visitors the services that can be rendered and the items that can be supplied besides optical flats and monochromatic lights for testing flatness. The exhibit will include seal rings, bushings, gages, examples of high finishes, lapped surfaces, etc. All of these are essential in one phase or another to the functioning of test equipment.

AMERICAN INSTRUMENT CO.

Booth 71

This company, of Silver Spring, Maryland, manufacturers of scientific instruments, will exhibit a group of their apparatus for A.S.T.M. and other standard tests. For cement there will be the new type 10-in. flow table, a cement autoclave and a Burmister flow trough; a California bearing test set for soil; the Yerzley oscillograph for rubber vibration absorption; the Modulimeter for the rigidity of plywood and laminated materials; the gum stability apparatus for petroleum; a Tuckerman strain gage, the Magne-Gage and Filmeter for measuring coating thicknesses on metals; and an abrasive wheel type cutting-off machine completes the varied group of instruments being displayed.

AMERICAN OPTICAL CO.

Booth 35

This Division, formerly Spencer Lens Company, will exhibit some new instruments. A new Metallurgical Microscope with Vertical Illuminator and a Bierbaum Microcharacter will be on display. A Polarizing Microscope in which Polaroid of optical quality replaces calcite, will also be exhibited, with accessories. Other standard microscopes and instruments of the well-known Spencer quality will be on hand.

H. REEVE ANGEL & CO., INC.

Booth 30

H. Reeve Angel & Co., Inc., will display their well-known lines of WHATMAN and REEVE ANGEL Filter Papers. Many of the WHATMAN Filter Papers are used in the methods of the American Society for Testing Materials. Both lines are distributed by all dealers in laboratory supplies. Papers for technical and industrial purposes will be featured.

ATLAS ELECTRIC DEVICES CO.

Booths 54, 55

This company will exhibit a specially constructed model of their Twin-Arc Weather-O-Meter which will be cut away to show the inside operating features of this popular machine. Visitors will be able to see how the Cycle Timer controls the light and spray cycles and other automatic functioning of the Weather-Ometer. In addition in the Atlas display will be shown for the first time the new stainless steel containers, 1 pt.—1 qt.—1 gal. for the Launder-Ometer.

BALDWIN-SOUTHWARK DIVISION, THE BALDWIN LOCOMOTIVE WORKS

Booths 14, 15, 16

The Model SF-2 Sonntag Fatigue Machine is a constant force type fatigue machine as contrasted with the constant deflection type. Other items to be displayed are the Sonntag plastics impact machine designed for the higher strength plastic impact specimens; Emery microload weighing system which extend the testing machine range down to 30 lb. The microformer stress strain recorder, a new electronic recorder operated on the transformer or variable voltage principle. Also modern plastics tools for physical testing of plastics, tension, compression, and flexure; a creep testing machine automatically recording and controlling for tests of metals at elevated temperatures; Model K portable strain indicator for SR-4 strain gage and a 48 point scanning recorder. Oscilloscopes, power supplies, amplifiers, pre-amplifiers, switching and balancing units for SR-4 strain gages, complete the display.

BOONTON RADIO CORP.

Booth 72

The display of Boonton Radio Corp. will include QX-Checker for comparing production parts with approved standard parts; beat frequency type 140-A, a generator of signal voltages; type 170-A Q-Meter and 160-A Q-Meter for measuring "Q" or ratio of reactance to resistance of a coil or condenser; also, a mica tester and spark coil test set.

BOWEN AND COMPANY, INC.

Booth 18

During the last five years Bowen and Company, Inc., devoted its facilities to the design and manufacture of various instruments necessary for the successful termination of the war. One of its noteworthy contributions was acting as pilot manufacturer of the renowned proximity fuse. The engineering and production departments are now busily engaged developing and manufacturing new instruments. The INTERFEROGRAPH, for photographing interference phenomena, will be displayed for the first time at the convention, along with other Bowen instruments.

BROOKFIELD ENGINEERING LABORATORY

Booth 48

This display will consist of viscosimeters, laboratory mixers, and other scientific and technical equipment.

BUEHLER, LTD.

Booths 65, 66

The Buehler exhibit at the A.S.T.M. Annual Meeting will feature an electrolytic polisher for quick, easy, and safe preparation of metallurgical samples without distortion of the most delicate structures. This polisher is being built in quantity and is priced to be attractive to every laboratory. There will be demonstrations of the polisher in operation. The complete line of sample preparation equipment including cutters, grinders, specimen presses, and polishers will also be represented. Metallurgical microscopes with new coated objectives will also be shown.

BURRELL TECHNICAL SUPPLY CO.

Booths 51, 52

Burrell will unveil in action the Turner-Burrell Adsorption Fractionator for the automatic analysis of light hydrocarbon gas mixtures. This development to be displayed for the first time, in Buffalo, is of importance to the petroleum and fuel gas industries as well as to those concerned with research and processing in the light hydrocarbon field. Work has been under way for several years on this apparatus. In addition, the Burrell booths will show a variety of manual gas analysis apparatus, high-temperature electric furnaces, the Barrett coal ash fusion furnace, titration apparatus and other specialized laboratory equipment.

CANADIAN RADIUM & URANIUM CORP.

Booth 34

The theme of this exhibit will be that of visual education through the use of slides projected on a screen. These illustrations of gamma ray technique will be supplemented by an exhibit of a casting setup with all the necessary equipment employed in this form of nondestructive testing.

CENTRAL SCIENTIFIC CO.

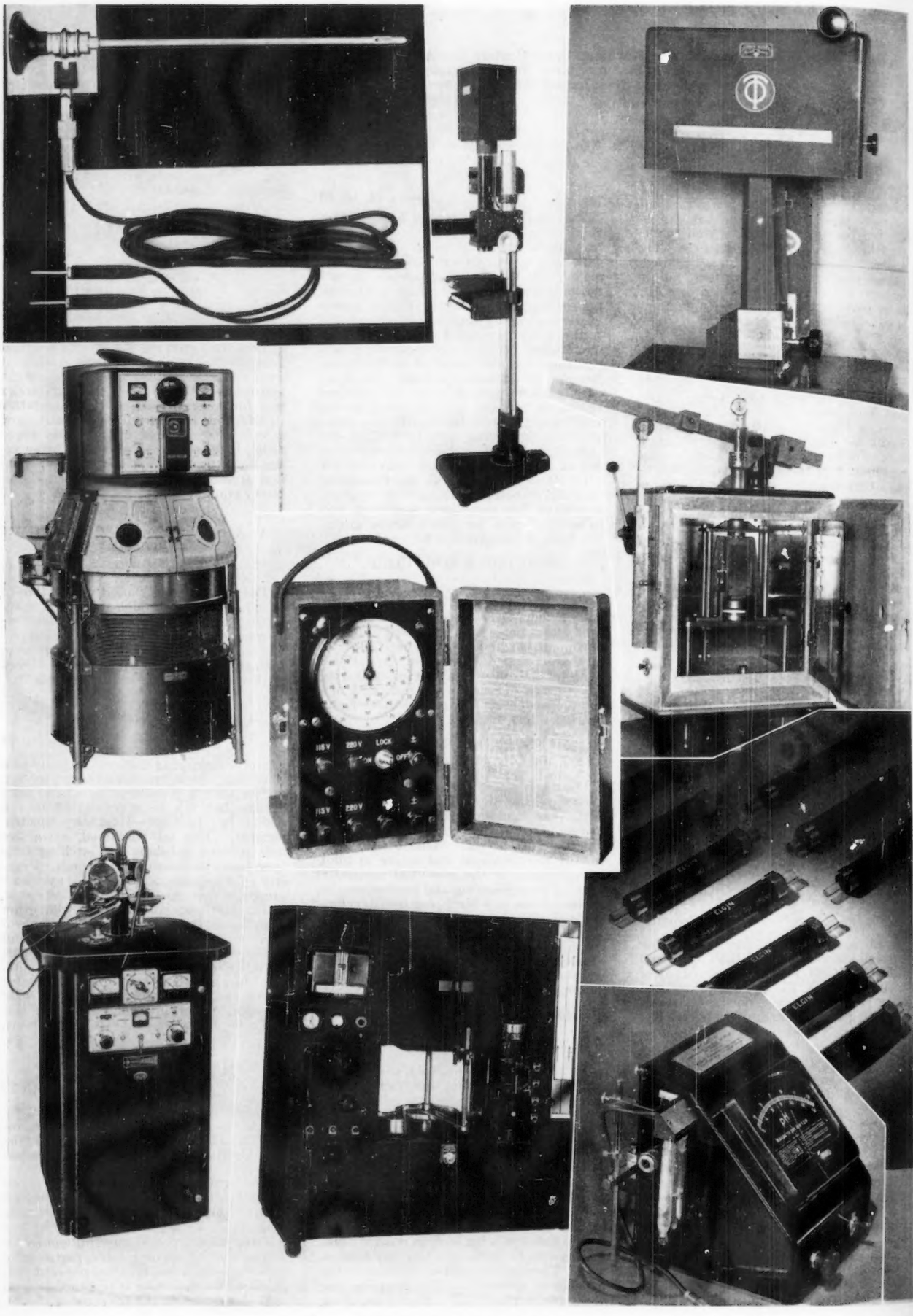
Booth 74

Metal specimens that are properly polished and etched for microscope examination in less than a minute is a metallurgist's dream that has been translated into a reality by the Cenco-Hangosky Electropolisher. This self-contained, attractive unit reduces polishing and etching time from hours to minutes and seconds. Properly polished and etched samples are easily prepared from: low and high carbon steels; stainless steels; and most of the other complex alloys containing small amounts of iron; cast steels and irons; nickel and nickel alloys; bearing metals; copper; brass; aluminum; zinc; cadmium, etc. The apparatus incorporates features for safety and convenience and offers a wide selection of current and time. See this and other apparatus in the Cenco exhibit.

THE COMTOR COMPANY

Booth 33

Rapid, precise, production line inspection of the quality of surface finish is provided by the Comtor Quick-Scanning Surface Comparator exhibited by this company. This instrument operates by reflected light which is picked up on a photo cell and the resulting electrical output greatly amplified to give a direct meter reading in terms of comparison with a selected standard. Minute differences in surface quality are detectable, particularly in fine finishes. One hundred per cent production line inspection is practical and no skill is required of the operator.



Upper Left: Boroscope for Internal Inspection of Tubes, etc.; Top Center: Interferometer; Top Right: A Newly Designed Impact Machine, Especially for Plastics; Center Left: Accelerated Weathering Apparatus; Center: A Versatile Cycle Counter for Testing the Operating Time of Over-Current and Under-Voltage Relays; Right Upper Center: Parallel Plate Plastometer; Lower Left: X-ray Diffraction Apparatus; Bottom Center: An X-ray Apparatus; Lower Right, Top: Plug Gages; Lower Right: New pH Meter.

EASTMAN KODAK CO.

Booth 13

This exhibit will center its emphasis on photography's function in industry. "The World's Largest Radiograph," 12 ft. 1 in. long and 4 ft. 8 in. high, will be featured. In addition, X-ray diffraction patterns, photomicrographs of foundry sand in full color, spectrographs, and photo layout materials will be displayed. A 20-page booklet, "Functional Photography," will be distributed. Technical representatives will be present to answer questions concerning the use of Kodak materials in industry.

ELGIN NATIONAL WATCH CO., SAPPHIRE PRODUCTS DIV.

Booth 70

Elgin Sapphire, noncorroding, hard wearing, true dimensional plug and ring gages which save man-hours, material and money while increasing production. These gages have outworn some types of steel phenomenally. The Elgin Micrometer, tipt with clear or ruby Sapphire, is guaranteed to 0.0001 in. It has produced more than 2,500,000 gagings without wear. In addition to gages and micrometers, Elgin is also manufacturing Sapphire tipt dial indicator points, standard shapes (wear surfaces) special burnish-cutting tools and styli. Many additional items are now being developed.

ENGINEERING LABORATORIES, INC.

Booth 23

The Penetron, complete with all auxiliary equipment and a working model of the fluid density recorder and liquid level locator is to be shown at this annual meeting of the A.S.T.M. This 25-lb., highly portable model is extremely useful for the purposes mentioned, as well as the measurement of wall thickness of lines or vessels without access to their interior. All of these functions are accomplished rapidly and accurately by means of the penetrating gamma ray.

GAMMA INSTRUMENT CO.

Booth 56

This display will feature their complete line of pH measuring apparatus, equipment for electrometric titrations, photomicrographic mirror reflex camera, and micro manipulators. Most of these units are recent developments and they incorporate many significant improvements. The main feature of all Gamma instruments is their simplicity of operation which relieves the operator of manual adjustments. This is especially true of the Gamma pH Meter. This apparatus is called automatic because of the manner of interlocking all preliminary adjustments and of the complete elimination of moving parts which require hand operation during measurements. The Microflex camera employs the mirror reflex principle in such a manner that the microscope can be operated conveniently while the image is observed and focused on the ground glass. In addition to the convenient way of focusing, the camera offers other features.

GENERAL ELECTRIC CO.

Booths 87, 88

This display, sponsored by the Apparatus Department of General Electric, will cover many of their instruments for testing and evaluating various materials and products including the magnetic comparator, fatigue tester, cushioning meter, photoelectric recorder, hook-on volt ammeter, core plate enamel tester, and the magnetic field gage. Other items are the standard roughness specimens, strain gage, flux meter, Gauss meter, magnetic hardness tester, radiation meter, insulation resistance meter, thickness gage, type.

GENERAL RADIO CO.

Booth 26

Among the features of the General Radio exhibit will be a display of photographs taken with the Microflash, a new light source whose flash lasts only 2 millionths of a second. A feature of the apparatus display will be an advance showing of a new line of Variac autotransformers. Also on display will be stroboscopes, noise and vibration measuring equipment and impedance bridges for measuring the dielectric properties of insulating materials. There will be other items for radio and electrical laboratories.

HANOVIA CHEMICAL AND MANUFACTURING CO.

Booth 64

This comprehensive exhibit will consist of fused quartz in various vessel forms, including quartz cells and apparatus which have been established as standards for test purposes. A feature of the quartz exhibit will be apparatus of extreme clarity and containing a minimum of air bubbles. High-pressure mercury arcs in quartz and high-voltage discharge tubes in quartz will also be shown. These light sources are very satisfactory equipment for work involving ultraviolet radiations and the blue and green lines of the visible spectrum. The new differential Hanovia Ultraviolet Meter will be shown. This is a direct reading indicating type instrument.

KEWAUNEE MFG. CO.

Booth 67

This booth display will include laboratory furniture but the exhibit will be built around Kemrock. The company will be running tests during the meeting where interested people may see how this material reacts to the various chemicals ordinarily found in a laboratory. Among those in attendance will be the Chief Chemist, Gordon Dillon, who will be pleased to answer questions on this product. Applications of this interesting material will be covered. It is used on laboratory tables, sinks, troughs, fume heads, etc. New uses are constantly being discovered.

KIMBLE GLASS CO.

Booth 89

This display will comprise the Kimble laboratory glassware which is widely used to meet the varied and exacting requirements of research analysis and control in science and industry. Many of the products are used in connection with evaluations and testing of materials.

KROUSE TESTING MACHINE CO.

Booth 73

Controlled elevated temperatures and speed are among the many outstanding features of the Krouse Testing Machines on exhibit in Booth 73. Direct stress, rotating beam and bending machines operate at maximum speeds of 1750 to 12,000 rpm. The High Temperature Machine produces even heat distribution over the entire length of the specimen, by means of a shunt wound furnace. The control unit accurately maintains the temperature to within ±2 deg. over a range of 200 to 1800 F.

MACBETH CORP.

Booth 68

The Macbeth Corporation will display principally its newly announced line-operated, continuous indicating pH Meter. This meter is of a radically new design employing glass electrodes. The principal features of this equipment are: Line-operation, continuous indication, direct reading, simplicity of operation. The Macbeth Corporation will also display standard daylight lamps for use with colorimeters in oil colorimetry.

MAGNAFLUX CORP.

Booth 50

This corporation will exhibit at the Annual Meeting and Exhibit of the A.S.T.M. examples of parts which have been inspected with Magnaflux, Magnaglo and Zyglo materials. Demonstration parts illustrating Stresscoat will also be on exhibit. No operating equipment will be displayed but a considerable number of articles, reports, and other data will be available for those interested in furthering their knowledge in the application of these inspection and stress analysis methods.

NATIONAL RESEARCH CORP.

Booth 49

The Alphatron Vacuum Gauge, operating by the ionizing power of alpha particles from a radium source, measures total pressure of any gas or vapor from 0–10 mm. Hg to the nearest 0.001 mm. with instantaneous linear response. Sensitive and accurate in reading but durable and simple for industrial use, this gage covers an important pressure interval which has not been adequately gaged heretofore.

Other items to be covered in this booth display include ionization and thermocouple gages and controls, a flexible laboratory pumping system, and diffusion pumps.

NORTH AMERICAN PHILIPS CO., INC.

Booths 36, 37

This organization will display the NORELCO Geiger-Counter X-ray Spectrometer and its associated equipment and will also show a number of X-ray diffraction (film-type) cameras. The Spectrometer, an exclusive development of the company, solves analysis problems which have been impossible by other known methods. It has an automatic strip chart recorder which literally makes an X-ray "fingerprint" of any substance. X-ray diffraction cameras are necessary accessories used with conventional film-type apparatus. These cameras are made in a number of different varieties to accommodate various specific problems. Film-type diffraction equipment has been in use many years for basic research. The Spectrometer is only about a year old and has many speed advantages over film-type apparatus. Instead of recording the data on film, the spectrometer reads intensities and angular relationships direct on instruments. This, of course, only takes a matter of minutes.

TINIUS OLSEN TESTING MACHINE CO.

Booth 75

While this company is not displaying its Standard Universal Testing Machines nor the Plastiversal Testing Machines at the A.S.T.M. exhibit, there will be photographs and data on file covering the wide range of sizes and types available. Several new types of testing apparatus are to be featured as follows: Wearometer—abrasive testing machine for determining the wear resistance or surface marring properties of materials; Parallel Plate Flow Tester—for determining the flow properties of thermoplastics, etc., at different temperatures; Impact Tester—"Change O Matic"—indicates shock resistance (Charpy and Izod tests) of all materials. Capacities 200, 100, 50, and 25 in.-lb.); Johnson Shear Tool—(Witt-Wolfe Design) for determining shear strength of all types of plastics and electrical insulating materials; Rubber Hardness Tester—for determining the hardness of rubber and similar materials; Stiffness Tester—for evaluating the bending properties of paper, plastics, wire, sheet metal, etc. New sensational devise for determinations. Don't miss it. Name to be selected by guests of the Olsen exhibit.

PARR INSTRUMENT CO.

Booth 22

This company will display its self-sealing oxygen combustion bombs and its adiabatic oxygen bomb calorimeter, as well as six different sizes and types of sodium peroxide bombs and various items of accessory apparatus. Of special interest will be an exhibit of Parr apparatus for hydrogenation and other pressure reactions, together with samples of a new line of alloy autoclaves having a simple closure design capable of holding pressures up to 15,000 psi. Parr engineers will be on hand to answer questions concerning the manufacture of special laboratory apparatus required for research programs involving the use of high reaction pressures and temperatures.

PICKER X-RAY CORP.

Booths 90, 91

This leading company will show its X-ray Diffraction equipment including a complete line of cameras and accessories. The latter includes film cutters for the various cameras and a measuring illuminator. There will also be shown a 50-kv. Industrial Radiographic unit which is used as a research tool and also for examination of spot welds on light metals and thin sections of other metals and materials.

PRECISION SCIENTIFIC CO.

Booths 41 and 42

This exhibit will consist of photographic displays showing many of the company's large number of items and also actual equipment covering recent developments in scientific research, production and control equipment in the petroleum, rubber, and plastics fields. A constant temperature cabinet will be shown as well as metallurgical specimen preparation equipment and electronic instruments. Precision will feature their new Aqua-raters using Karl Fischer Methods. Several of the instruments will be in operation.

RADIUM CHEMICAL CO., INC.

Booth 24

Representatives of this company will be in attendance in Booth 24. On display will be radiographs taken with radium as the energy source. The representatives will demonstrate techniques and handling equipment for use with the radium. A few minutes spent at this booth will be well worth while, since radium—a nondestructive testing tool in laboratories and foundries, as well as in the field—is a subject that is meeting with world-wide acclaim from technical men.

RAINHART CO.

Booth 12

A number of new test devices will be featured in Booth 12 by Rainhart Co. They have acquired the C. Raines & Co., Ltd. equipment business and are now specializing in soil mechanics and construction test equipment. Their services include custom design and production of equipment and those attending the meeting will have an opportunity to discuss special needs with the Engineering Manager, Mr. Charles C. Raines, who is a specialist in this field.

RIEHLE TESTING MACHINES DIVISION

AMERICAN MACHINE AND METALS, INC.

Booths 61, 62, 77

This company will exhibit a 300,000-lb. capacity precision hydraulic compression testing machine, Vickers Pyramid hardness tester, combination Izod-Charpy tension impact tester and various measuring instruments and testing devices.

RUBICON CO.

Booth 38

Photoelectric photometers for chemical analytical applications and for color grading work are among the newer items included in the Rubicon exhibit. Spotlight galvanometers, precision potentiometers and resistance measuring equipment will also be on display.

SCOTT TESTERS, INC.

Booth 25

Scott Testers, Inc., formerly Henry L. Scott Co., will feature their new development—a constant rate of load drive as applied to the conventional pendulum type of textile tester. This new drive, electrically increases or decreases the speed of the driven clamp to eliminate from the upper clamp, or loading end of the tester, the effect of stretch in the sample. In the conventional drive the rate of load applied to the specimen is variable because the stretch of the specimen is subtracted from the constant speed of pull. The new electronic drive is actuated by a control attached to the loading head of the tester which varies the speed of the pulling clamp. The design is such that by a small switch the tester is immediately changed over and operated in accordance with the existing conventional specified conditions. Another feature is a newly developed fabric clamp. Considerable difficulty was experienced in gripping synthetic yarn fabrics so that slippage during the test would not cause a premature break. The new clamps, holding more firmly at the front edge than in the rear, grip the fabric so as to minimize slippage and obtain more correct tensile values.

SPERRY PRODUCTS, INC.

Booth 27

This exhibit will feature the SUPERSONIC REFLECTOSCOPE and the THRURAY. The SUPERSONIC REFLECTOSCOPE is an instrument for the nondestructive testing of metals for internal defects. It sends supersonic vibrations through the material under test and measures the length of time it takes these vibrations to penetrate the material, reflect from the opposite side, or from an internal defect, and return to the sending point. A pattern produced on an oscilloscope screen provides a visual indication of the location of any defects that may be present. The THRURAY, also a supersonic instrument, is designed for the production testing of metals where only an indication of the presence or absence of the internal flaw is essential. This is obtained by replacing the oscilloscope with a dial indicator.

STANDARD ELECTRIC TIME CO.

Booth 11

This company's exhibit will consist of a display of Precision Electric Timers and Chrono-Tachometers and also a sample board showing the jacks, plugs and binding posts used in making custom-built test equipment and electrical distribution systems. The Timer display in addition to standard timer models will have a unit which can be operated by visitors for testing the operating time of a relay, a working model of a high-speed electric counter (2500 counts per min.), and a millisecond timer (accuracy plus or minus 0.0002 second per operation). One of the Chrono-Tachometers, almost universally used for aircraft engine and propeller governor tests, will be on display. There will be a portfolio of photos of custom-built test equipment on hand. The personnel will be glad to discuss timing and speed measurements.

STATHAM LABORATORIES

Booth 39

Simple electrical means for remote indicating and recording of displacements as small as 0.000008 in. will be one of the features of the Statham exhibit. This instrument, as well as others for measurement of pressure, flow, force, and acceleration, will be set up for operation. Based on the Statham Unbonded Strain Gage, these sensitive, precise instruments produce electrical output ample for direct operation of indicating and recording meters without need for electronic amplifiers.

C. J. TAGLIABUE DIVISION
PORTABLE PRODUCTS CORP.

Booth 53

This Division, makers of Indicating, Recording and Controlling Instruments, will have an interesting display of many new and improved instruments for testing materials, including all the recent developments: TAG CELECTRAY Throttling Indicating Controller; the vibration-proof CELECTRAY Indicating Controller; and the CELECTRAY Multiple Point Temperature Recorder. The TAG Moist re Meter, "dielectric" type, which supplements the present line of TAG-Heppenstall Moisture Meter for grain, lumber, tobacco, etc., and extends the field of moisture measurement by electrical instruments to powders, will also be on display, as well as the complete line of TAG Petroleum Testing Instruments, Chemical Thermometers and Hydrometers.

W. M. WELCH MFG. CO.

Booth 81

This company, with headquarters in Chicago, will display in its booth No. 81 their complete line of Duo-Seal Vacuum Pumps; also several models of stainless steel laboratory balances and a complete line of electrical meters. Other items include atomic chart, stirrers, hydrogen ion apparatus, resistance boxes, and rheostats.

WILL CORP.

Booth 10

Carbon monoxide in relatively small concentrations is a potential hazard in many industrial operations. It combines with hemoglobin in blood causing internal asphyxiation. Consequently, a simple, accurate and reliable instrument for rapid determination of carbon monoxide in any type of atmosphere is of great value not only to eliminate physiological dangers, but also to help design, adjust and operate industrial appliances to secure proper combustion. The Will Corporation will exhibit, among other items of laboratory equipment, a portable carbon monoxide measuring apparatus capable of determining CO down to 25 parts per million reproducibly and trace indications down to 3 to 5 parts per million.

WILSON MECHANICAL
INSTRUMENT CO., INC.

Booth 69

This display will include current models of the "ROCKWELL" Hardness Tester and "ROCKWELL" Superficial Hardness Tester which have all the new improvements, including stainless steel elevating screw, stainless steel plunger rod, totally enclosed testing head and dial gage. All operating controls are conveniently located. Various accessories will be available for demonstration including the "EQUITRON" fixture which is recommended for supporting either the preferred, optional or L-bar specimen for the hardenability test. In operation will be the latest model TUKON Tester with "Knoop" Indenter, which instrument may be used for micro-hardness testing of metals. This instrument may be used for testing nonmetallic materials, such as plastics, glass, ceramics, and even jewels, such as sapphire and diamond. The TUKON Tester will be equipped also with the 136° diamond indenter so that the diamond pyramid hardness number may be obtained.

Photographic Exhibit

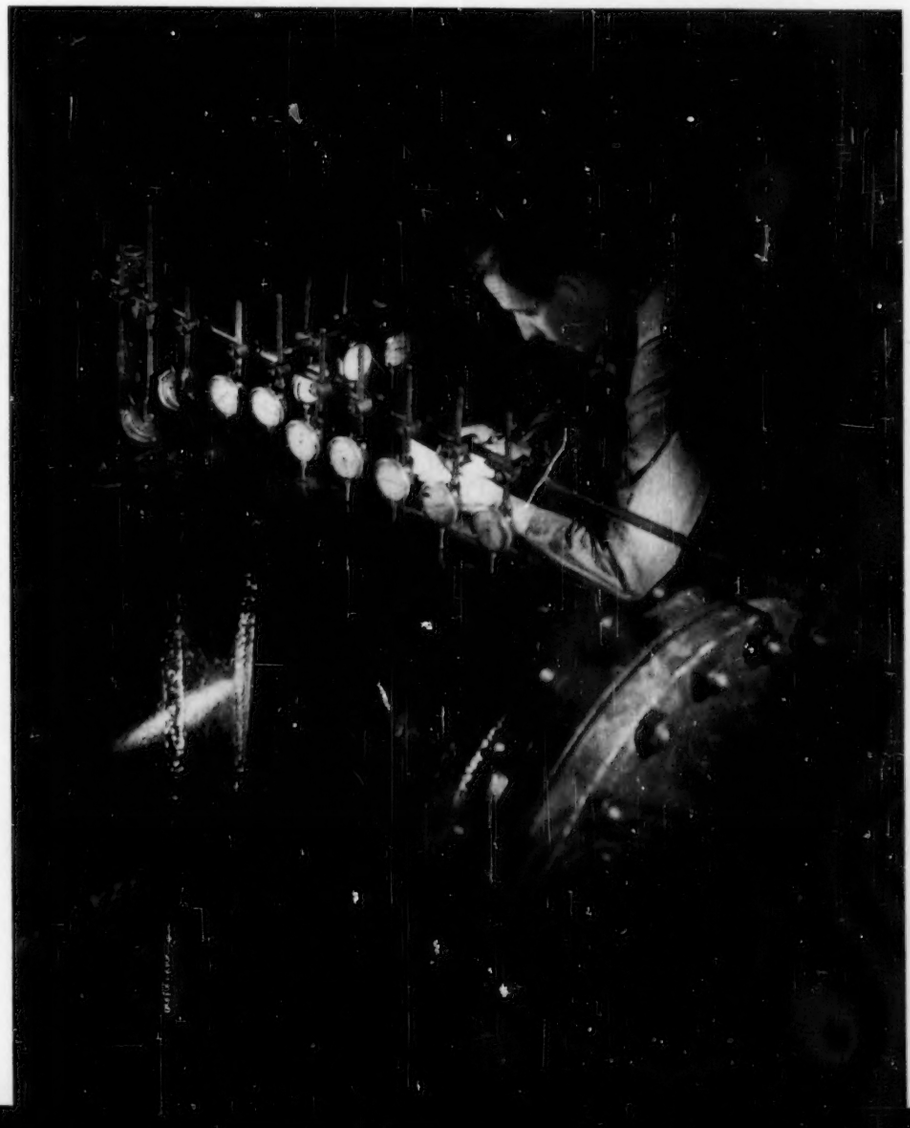
THOSE members who are planning to participate in the 1946 Photographic Exhibit whether in the general section or those concerned with photomicrography or radiography are urged to advise the committee in charge of their intentions. A letter can be addressed to T. L. Mayer, Buffalo Public Library, Buffalo 3, N. Y., and the entry blank and the photographs can follow in due course. June 17 is the last date for receipt of entries.

Each member and committee member of the Society received a prospectus describing the exhibit which also provided an entry form.

The theme this year is: Materials, Testing and Research. Committee E-4 on Metallography is sponsoring the section of the exhibit dealing with photomicrography, which includes work with the electron microscope; and Committee E-7 on Radiographic Testing is sponsoring this section of the exhibit. Extra copies of the Photographic Prospectus-Entry Form can be obtained from A.S.T.M. Headquarters.

"Measuring Deformation of a Pipe Header Under Pressure"

First prize-winning photograph, nonprofessional, in the Fourth A. S. T. M. Photographic Exhibit, 1941, by W. C. Wilke, Crane Co.



American Ceramic Society News; Ross Purdy Retires

A NUMBER of interesting activities took place at the 48th Annual Meeting of the American Ceramic Society held in Buffalo at the Hotel Statler from April 29 to May 1. (The Statler is the headquarters hotel for the 1946 A.S.T.M. Annual Meeting beginning June 24.) Several A.S.T.M. members were prominent at the meeting, including J. D. Sullivan, Assistant to the Director, Battelle Memorial Institute, who is the new A.C.S. Vice-President. Mr. Sullivan is Chairman of A.S.T.M. Committee C-8 on Refractories. J. E. Hansen, Director of Service, Ferro Enamel Corp., Cleveland, Ohio, is the new President for 1946–47. Dr. George L. Clark, University of Illinois, delivered the annual Edward Orton, Jr., Fellow Lecture on the use of X-ray in research in ceramics. In 1927 Dr. Clark delivered the A.S.T.M. Edgar Marburg Lecture on the subject, X-rays in industry.

Perhaps of greatest interest, from the personal standpoint at least, to a great many of his A.S.T.M. friends, was the retirement as longtime General Secretary and Editor of the American Ceramic Society of Ross C. Purdy. Active in this capacity since 1921, he had several years earlier been a president of the society and continued his activity in various capacities until he became Secretary. Dr. Purdy has represented the A.C.S. membership in A.S.T.M. since that time and has encouraged a policy of cordial cooperation in those fields of work, predominately refractories, where there is a mutual interest. The society, however, is represented on many other A.S.T.M. technical committees.

Elected to succeed Dr. Purdy was Charles S. Pearce, formerly Secretary of the Porcelain Enamel Institute, a native of Wichita, Kansas, a graduate of Ohio State University, and connected with the porcelain enamel branch of the industry for many years.

American Foundrymen's Golden Jubilee Convention

SOME 150 technical papers, reports, addresses, etc., were presented during the Golden Jubilee Convention of the American Foundrymen's Association held in Cleveland during the week of May 6. In connection with this 50th Anniversary Meeting there was an extensive exhibition of foundry equipment.

One of the high spots of the week, the fourth annual A.F.A. Foundation Lecture, was presented by Dr. G. H. Clamer, President, Ajax Metal Co., Philadelphia, who is a past president of both the A.F.A. and A.S.T.M., is an A.F.A. Gold Medalist and one of the most active and respected men in his field. The subject of Dr. Clamer's address was "Test Bars for 85 Copper-5 Tin-5 Lead-5 Zinc Alloy—Design and Some Factors Affecting Their Properties." This presented for the first time the data on test bars which have resulted from the investigation of test bar practice by Battelle Memorial Institute in research work sponsored by the Non-ferrous Ingot Metal Institute. It is the opinion of those associated with the foundry trade that this is one of the most important contributions to foundry work in many years. The data have revealed information which is of direct interest to A.S.T.M. Committee B-5 whose Subcommittee on Castings and Ingots, of which Dr. Clamer is chairman, expects to make extensive use of this information in drawing up a recommended practice of tension tests of copper-base alloy castings. In this work it is expected that A.F.A. as well as all specification groups interested in the subject will cooperate with A.S.T.M.

Many other A.S.T.M. members who participate in foundry work contributed to the meeting. A.S.T.M. member Max Kuniansky, who is Vice-President and General Manager, Lynchburg Foundry Co., Lynchburg, Va., was elected Vice-President of the A.F.A. Hyman Bornstein, Director of Testing and Research Laboratories, Deere & Co., Moline, Ill., past president of the A.F.A., and also very active in the work of A.S.T.M., was the recipient of the A.F.A. William H. McFadden Gold Medal "for his many and outstanding technological contributions to the foundry industry, particularly in the field of gray cast iron." Two other men who have been interested in A.S.T.M. work also were honored by the A.F.A.: William J. Coane, Vice-President, Ajax Metal Co., Philadelphia, and Harold J. Roast, Vice-President of Canadian Bronze Co., Ltd., Montreal, received honorary life memberships. The annual address was delivered by A.F.A. President Fred J. Walls, International Nickel Co., Inc., Detroit.

Books for War Devastated Libraries

THE American Book Center for War Devastated Libraries, Inc., has sent out an appeal to all those who have excess material that any books and related contributions be sent to the American Book Center, c/o The Library of Congress, Washington 25, D. C. A group of leading librarians comprises the officers of this worthy project and they have pointed out that what is particularly desired are scholarly books which are important contributions to their fields, also periodicals (even incomplete volumes) of significance, and fiction and non-fiction of distinction. The committee stresses that in general there is *no* need for textbooks, outdated monographs, recreational reading, books for children and young people, light fiction, materials of purely local interest, popular magazines, etc. All shipments should be sent *prepaid via* the cheapest means of transportation. The Center *cannot accept material which is sent collect.*

The one thing that has been proved to me again and again from these hundreds of reports and my own personal observations is that in war, as in peace, the combined effort of free men is the potential behind the greatest accomplishment this world has ever known.

A democratic government, and free, competitive enterprise, is more efficient and more productive than a dictatorship any day, any time, any where!

From an address by John H. Frye, Columbia Steel and Shafting Co., formerly Colonel, U. S. Army, Ordnance Department, on the subject "Steel Fabrication—General Review of German Metallurgical Practices" published in *Metal Progress.*

Materials Engineering at Home and Abroad[1]

By J. R. Townsend[2]

WHEN I visited California for the first time about four years ago, I saw the beginnings of a great new industrial area. There were many new manufacturing plants and it was evident that these companies were making the parts and components needed to build ships and airplanes. The tendency appeared to be for the large fabricating industries to look to smaller companies for parts and specialties such as die castings, plastic molded parts, and heat treatment, laboratory testing, and welding. This is a very healthy situation since, in such an atmosphere, new companies willing to risk new ideas have a chance to get started. This is a most important path to progress. On my return, I was full of enthusiasm over the situation and prevailed upon our Secretary and President, Messrs. Warwick and Harvey to visit this area in 1944. That trip was most valuable in bringing to A.S.T.M. the current thinking of engineers in the aviation and shipbuilding business. The needs of engineers in this area were explained and A.S.T.M. has responded by making radical reorganization of the Society's work and objectives. If we are to serve best the needs of engineers, we must keep up to date and foresee, if we can, future trends. We are here again and our mission is the same. We are also anxious to test our plans and see if they are bringing to you the results we have hoped for.

There has been started here in California an entirely new approach to manufacture. This has grown out of the needs of the war for thousands of ships and airplanes. These were delivered in time and their number and excellence overwhelmed our enemies. Many new lessons in manufacture have been learned here and these lessons are going to be applied to the building of commercial airplanes, houses, cars, and the thousand and one items needed in modern life. These contributions were not solely new materials, or quantity production, or an inspired design. They had principally to do with a new kind of "know-how" based on new fabrication methods, organization, and modern plants designed to be comfortable and pleasant places to work. The climate, and educational and recreational possibilities of California contribute to making this an industrial area that will bear watching.

Materials engineering has been an important part of these developments. When I was here before, I was much impressed by the Aircraft War Production Council. These men were exchanging ideas, and it was evident that the problems they were meeting required radical revision of our knowledge of materials and of fabrication. The era of prefabrication that is getting under way here and elsewhere demands study of composite structures, parts and assemblies, components, and sandwich materials. This greatly complicates the problem of deterioration and fatigue, corrosion, the effect of heat and cold, and severe unit stresses usually repeated or of a dynamic nature. Design based on static material testing without environmental testing was hopeless in producing results that could be used. Army and Navy tests were based on performance under simulated or exaggerated service conditions. The designer could not take a chance on building something that would stand the navy pitch and roll machine, or operate at −100 F.; he had to have exact knowledge of the behavior of materials and parts. The old A.S.T.M. methods were useless in coping with these new requirements. They were accordingly revised and we are now planning further revisions and have reorganized our Society to be in a position consciously to follow the trends in science and industry and be in position to anticipate, plan and devise tests and methods so that they will be ready when they are needed.

Mr. Warwick has told you of the Special Study Committee and how our new Board of Directors will function. He has also explained the work of our new committees on parts and assemblies, sandwich materials, adhesives, consumer commodities, environmental testing, and the development of new test methods in the field of spectroscopy. Collectively this constitutes a new field of engineering known as Materials Engineering. It is a most important and rapidly growing field of engineering interest. I would like to give you some examples of my experience in this field and to compare the work in America with what I was privileged last summer to observe in Germany.

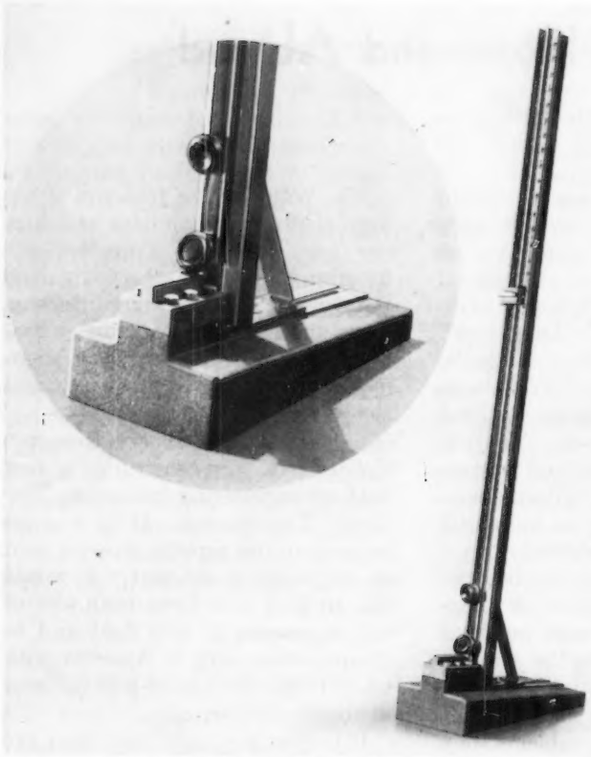
It is clearly evident that there are more materials now available than any design engineer can be expected to know. For example, in the plastics field the period since 1918 has produced 125 trade-named products and 70 types of compound. Each type of compound has many grades and hardnesses. For example, one manufacturer had cellulose acetate in 6 grades, 17 hardnesses, 4 compression hardnesses, and 13 injection hardnesses.

This calls attention to the need of simplification. Obviously, we do not need so many different kinds of plastics. Many of these plastics are intended for one and the same purpose. To differentiate requires precise testing. There are now several recognized tests for plastics and A.S.T.M. has issued 67 specifications. Considerable coordination of producer and consumer was necessary to accomplish this task.

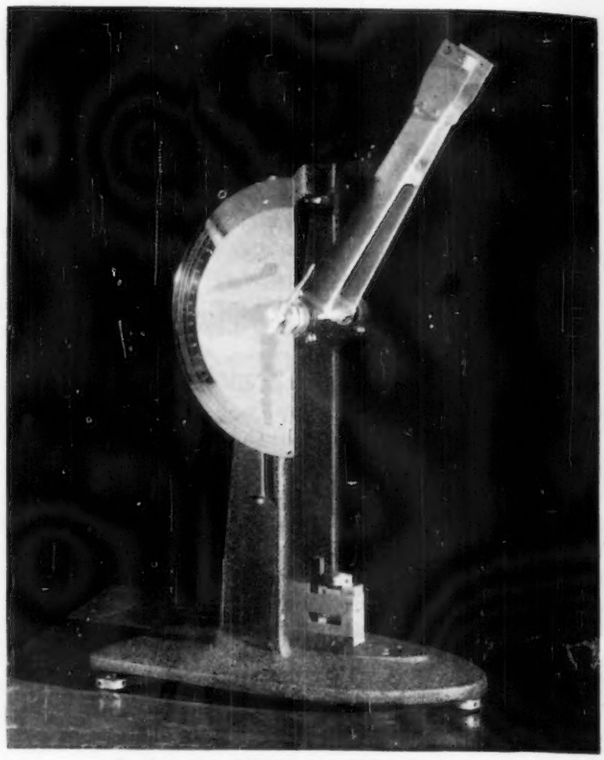
Much of the information required to get out an informed design involving plastics has never been available. The producers are familiar with their product but cannot be expected to anticipate all of the uses to which their materials will be put, or the effect of the environment upon the material. In addition to the intelligent producer backed by his research staff and concerned with the manufacture of

[1] Presented at A.S.T.M. District Meetings in Southern California (Los Angeles), March 19, 1946; Northern California (San Francisco), March 25, 1946.

[2] President, A.S.T.M., and Materials Engineer, Bell Telephone Labs., Inc., New York, N. Y.



Handset Dropping Test.



Izod Impact Machine for Testing Plastics.

the material, we must have a consumer who knows precisely his needs. These must be defined in terms of tests that producer and consumer can agree upon. Such a consumer may be said to be the best kind of a consumer since he can tell the producer exactly what he wants. This is the kind of consumer the Bell System wants to be and this is one of the reasons we, along with other large corporations, have organized large industrial laboratories. An important part of the work of such laboratories deals with the characterization of materials, products, and components.

An example from my experience might serve to illustrate the functioning of materials engineering.

We were anxious to try out a plastic combined telephone set consisting of a mounting and a fully insulated handset. The handset was made of phenol plastic and had been in use for a number of years. Dropping tests on the handles correlated with impact tests on molded impact bars gave us a control test for strength. The impact test bar we designed is now standard for the industry. The housing, however, was a different story. Ordinarily, we would have proceeded slowly to develop a mounting designed to bring out the best possibilities of the molding art. Our hand was forced, however, by the need to find a substitute for the zinc-base die-cast housings we had been using. Zinc was needed for brass for cartridge cases. An initial experiment using a die-casting die showed we could make an injection-molded housing. We quickly adopted this design with a few modifications, mainly directed at reinforcing the plastic by placing ribs on the inside of the housing. This could easily be done with the die casting die since it was only necessary to cut grooves in the force.

Originally we employed cellulose acetate and two unexpected problems became of great importance. First, the housings dried out during the winter heating period and locked on the base. Tests further showed that this shrinkage was not only due to initial loss of moisture but, on rehumidifying, its original dimension was not restored. Furthermore, the shrinkage continued from year to year.

Another difficulty was that the shape of the housing required the plastic to flow in two streams and for these to meet at the back of the housing. The two streams welded but the weld was only one tenth of the strength of the base material. Studies of this problem led to a fundamental examination of the injection-molding process. Specimen molds loaded from opposite ends, so that welds could be formed in the center of tension specimens, were made. By varying the conditions of molding, such as temperature and pressure and also the compound, improvements were made.

At present we are using acetobutyrate and there are other promising materials undergoing study, such as cellulose acetate propionate and ethyl cellulose. All of these materials seem to be less affected by moisture than cellulose acetate and have improved weld strength. New designs of molds may eliminate the necessity for a weld. The problem of strength of weld, however, remains a basic one that must be studied in all injection-molding applications.

Furthermore, repeated impact is an important consideration in materials and design of substation apparatus. We were surprised to

find the impact fatigue of plastics to be so low. Apparently one hundredth of the force required to break a specimen, if repeated often enough, will cause fracture. Repeated blow impact fatigue is now established as an important quality of plastics.

We have exposed plastics to heat and cold and to humidity. Prolonged humidity proved to be an important test for plastics containing fillers, such as cotton flock and wood flour. If the flock was balled up or badly distributed it would expand and produce blisters. It was found later that boiling the part in water would produce the same result. This has since been adopted as a routine test of molded product made of phenol plastic.

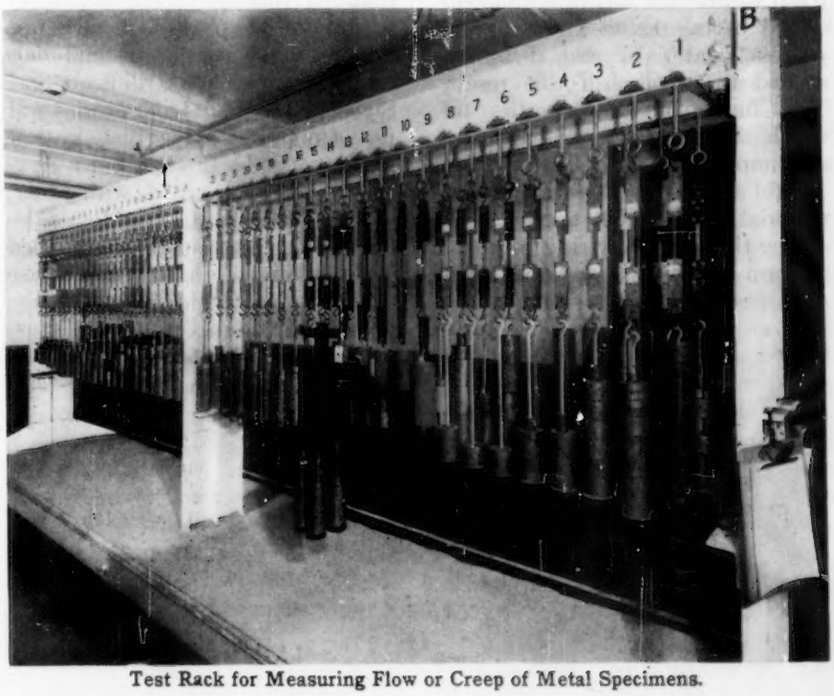
We were startled by the dulling and surface roughening of bakelite handles in the southern area of the United States. Investigation showed that these handles had been not only exposed to the high humidity of that area but had been left in direct sunlight as well. The Weatherometer originally designed to test paint surfaces would reproduce this result. The test is now broadly applied to all plastics. It seems that an environment of moisture, heat, and ultraviolet light will break down some composite organic materials and allow one to pick out those that will not stand up in service.

Next to the effect of low temperature upon lubricants, perhaps fungi attack provided one of the most difficult environmental problems that arose during the war. Fungi not only affected optical parts but ruined leather, insulation on wire and most common insulators. Some of the early communication sets were rendered useless in a short time when exposed to the tropics. Fungi tests were tried on materials of all kinds. It was found that not only fungi but also the nits or small bugs that grow in the tropics were necessary in any test to simulate service conditions. When these bugs died, and they died everywhere, fungi fed on their bodies. Fungi give off acids, particularly hydrofluoric acid, and this etches binocular lenses. Fungicides of all kinds were experimented with and finally the problem was solved by using materials unaffected by fungi and the use of fungicides. Insulating lacquers containing fungicides were sprayed over the electrical equipment. Heaters kept the relative humidity below 70 per cent so that fungi could not grow. Exposure tests were made in the tropics on all common plastics, textiles, papers, leather, and other materials of construction with and without fungicides.

To pass from the instability of plastics to the instability of metals, we have many examples. Metals fail due to both static stress and repeated stress. Static stress failures are the familiar season cracking. Some years ago, laboratory tests showed aluminum bronze to be ideal for ratchet wheels for one of the selector switches used in automatic telephone apparatus. After short exposure to service, failure by radial cracking occurred. Examination showed that the ratchet had been forced upon the knurled head of the steel shaft and no provision had been made for the chips of metal cut by the knurl. This placed the ratchet in heavy peripheral tension and intergranular failure of the metal took place. Undercutting to provide space for the chips and annealing after assembly eliminated further failures of this kind.

Shortly thereafter we had a failure of a ringer gong in a rather unexpected way. These gongs were cold-formed and then given a baked japan finish. These gongs were used by the millions and no trouble ensued. Later, as an economy measure, the finish was omitted. Failures by radial cracking immediately occurred. The elimination of the finish naturally left out the 4-hr. 450 F. bake, incidental to the japanning operation, had removed the strain in the metal. The bake or heat treatment was restored, but not the japan paint, and no further trouble was had.

Fatigue failure of relay, key and switch springs is now a thing of the past in telephone practice. We now measure the fatigue characteristics of all sheet metals for all stresses and grain directions, plot a Goodman diagram and design with the diagram. Fatigue failure of cable sheath is similarly a thing of the past. Installation practices have been improved to the point where failures are very rare indeed. Most failures are now due to unavoidable damage to the sheath, cuts, kinks, and similar stress raisers. We have devised tests to evaluate new alloys, test full-size cables and cable sleeves, and make creep tests. Microscopic examina-



Test Rack for Measuring Flow or Creep of Metal Specimens.

tion techniques have been developed and are broadly applied.

During the war period, the scarcity of materials required the use of substitutes. Also, substitutes had to be found for substitutes. Because we had the foresight to train a special organization in materials engineering, many of these substitutions could be carried out on a consulting basis. Thousands of War Production Board orders had to be read, interpreted, and changes made in the use of materials. Not a single day was lost in producing communication equipment for the Government or domestic use due to the scarcity of a material. This was accomplished by having on hand complete data files of information, materials specialists skilled both in the knowledge of the material, and also its methods of fabrication, and a fully equipped laboratory.

We have been developing materials specifications for years based on the conception of obtaining reproducible quality and quality control. Modern high-speed production methods require the building of elaborate and complicated manufacturing machinery. Processes are developed to get the most in speed and workmanship from the machine. This places the burden on uniform quality of material. The invariable machine requires an invariable material to produce accurately dimensioned parts. Exact knowledge of process, materials, and design is needed to accomplish this result. The fundamental properties of which the material is capable are also important. Statistical quality control applied to inspection of raw material and product proved itself during the war. Cartridge brass of uniform quality, checked by accurate tests for composition, grain size, and hardness, produced millions of accurately dimensioned and sound cartridge cases.

The setup of American production methods permitted rapid changes and improvements in design to be made without interruption of production. Modernization kits permitted the latest developments to be added in the field.

The situation in Germany, according to my observations, was different from that in America. Although Germany has led in fundamental scientific discovery, the broad application of such discoveries to the development of products available to all of her citizens was weak indeed. They went to war without experience in modern high-speed processes or control. Germany could not produce the quantity of weapons it needed even if it had the materials. There were few raw material standards, as we know them. Material was made to be fitted by a skilled workman and not to fit a high-powered high-speed machine. The result was that even though Germany enslaved millions to produce war implements, it could not compete with our quantity production methods.

I believe I have shown that materials engineering is necessary because of the complication and variety of materials available. Each new material brings new problems of process and the effect of environment. It is futile to use a new material without thorough investigation. High speeds, dynamic stresses, and composite materials render the problem a difficult one. Since in the Bell Laboratories our use of materials is peculiar, in that we do not sell a product but a service, we are concerned with wear, life, and deterioration. Metals deteriorate due to corrosion, trapped stresses, fatigue, impact, and phase changes. Organic materials—paints, varnishes, insulation, plastics—all deteriorate due to loss of solvent, plasticizer, polymerization, humidity, oxidation, light, and reaction with other substances. A complete scientific laboratory equipped with the latest chemical and physical research equipment is necessary. Yesterday the optical microscope and the spectrograph were important new tools; now we have X-ray diffraction, infrared spectrograph, and the mass spectrograph just coming into use. Science is being pressed by technology for new tools. It behooves us to support fundamental research to develop these tools and to understand the forces that render materials unstable in use. Whereas the fundamentalist is concerned with phenomena and their relationships, the engineer needs to know how to measure and use new materials and to assure a uniform level of quality of material for fabrication.

The Bell Laboratories' chemical and materials organization is designed to have scientists studying new materials and phenomena and to devise tests by which to judge or measure improvements or advancements in quality. We are organized into groups concerned with metallurgy, electrochemistry, organic finishes, dielectrics, ceramics, plastics, and electronic materials, as well as chemical, analytical, optical, X-ray, spectroscopic, and electronic optical instrumentation. Each division covers fundamental science, development, chemistry, and engineering. Standards and specifications originate in all groups but the editing passes through one set of hands. We have under development laboratories where full-scale preproduction processes in chemistry and metallurgy will be developed and brought to a successful stage of operation. We feel that the most cannot be had from design without designing to fit process.

Laboratory Testing of Consumer Goods[1]

By A. T. Chameroy[2]

THE American Society for Testing Materials and various other technical societies are certainly conscious of the problems of testing as they apply to materials. Programs now underway reveal that technical groups are working diligently to set up test procedures that will be of great assistance to laboratory people. Little work, however, has been done or is being done by any of the technical or industry groups on test procedures for finished items of merchandise. In presenting this discussion on the simulated service testing of consumer goods, no attempt is being made to sell you on the methods of test which we use at Sears. The material is presented in the hope that it will provoke thought on the subject and encourage the development of standard test procedures for consumer goods.

Types of Testing at Sears

At Sears, our test work on consumer goods falls into three general classifications:

1. Check testing to verify producers' claims. Information obtained by check testing may be used for various purposes, such as in writing sales copy, or other promotional material, or in ascertaining whether an item being shipped is meeting the specifications of the samples submitted by the source.

2. Comparative testing. We generally utilize comparative testing to compare the merchandise under consideration with samples submitted by other producers, or with similar merchandise being sold currently by others or, perhaps, with merchandise previously tested in the laboratory.

3. Fact-finding testing. As its name implies, this type of testing is used to obtain a wide variety of information concerning merchandise, such as: Of what it is made, how sturdily it is constructed, why users have complained about it, and how well it will serve the purpose for which it is intended, or, will it stand up under the conditions of service for which it was intended?

Testing Objectives

The great variety of products in daily use by the consuming public makes the job of testing these products a very complicated one. To do it well, all of the major technical sciences, chemistry, electrical engineering, mechanical engineering, home economics, physics, production engineering, and many others, must be brought into proper focus on the problem.

The main objective before us is the improvement of products for ultimate consumer use through good laboratory testing. To do this, we must, therefore, ask ourselves what good testing of consumer products will do. I think it can be summed up in the following four points:

1. It should help in the program of consumer education by furnishing facts for informative labeling and consumer-use instruction.

2. It should help to determine the expected life and usefulness of a product and, therefore, its value.

3. It should help to determine the weaknesses in a given product and result in a program to improve the product by correcting those weaknesses.

4. It should help to establish the various price levels of similar items sold within a given line. For example, if men's dress shirts are price pointed at $1.49, $1.98, and $2.49, good testing should help to determine whether or not the price differential is justified by comparative utility or style value incorporated in the shirts in the various price groups.

Testing Facilities

I am sure that all of us who are part of laboratory testing work are convinced that the work we do is of utmost importance. Are we always sure, however, that we contribute as much to the improvement of consumer goods as we should? If we say "No" to the question, then it certainly calls for further analysis of our work so that we can be certain that the results are useful and beneficial. This means that we should study and analyze the tools with which we perform our work.

The first consideration is, of course, physical facilities. It is taken for granted that anyone interested in testing consumer products will provide the necessary physical facilities that are needed for the type of testing to be done. In our work, due to the large range of products we test, we have found it necessary to have our physical facilities broken down into five divisions. These divisions are: (1) Chemical Laboratory, (2) Textile Laboratory, (3) Electrical Laboratory, (4) Home Economics Laboratory, and (5) Mechanical, Combustion, Refrigeration, and Air-Conditioning, and Automotive Laboratory.

The next consideration is the equipment essential for conducting the tests properly. This breaks down into two classes of equipment. *First*, there is the standard equipment commonly found in any modern testing laboratory such as variable temperature rooms and wind tunnels for refrigeration and air conditioning laboratories, dynamometers for automotive laboratories; Fade-o-meters; Launder-o-meters; breaking-strength and abrasion machines for textile laboratories. *Second*, there is the equipment which falls into the classification that we call "special purpose machines." These are pieces of equipment which have been specially

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Talk presented at a session sponsored by the A.S.T.M. Chicago District as part of the Chicago Production Show and Conference held at the Stevens Hotel, March 22, 1946, Panel No. 38.

[2] Manager, Merchandise Testing and Development Laboratories, Sears, Roebuck and Co., Chicago, Ill.

built to conduct certain types of tests. They are not standard equipment and, therefore, cannot be purchased from commercial producers of testing equipment.

The next requirement is a staff of competent technical people who, by education and training, have the knowledge that is necessary to set up, run, and interpret the results of tests. They also must be capable of writing intelligible reports that convey to producers and distributors the meaning of these tests.

Test Procedures

The next, and probably the most important requirement, is a knowledge of the type of tests that are necessary to evaluate properly the products to be tested. This is what I call formulating standard test procedures. Without a prescribed method of test, it is impossible to evaluate results, nor is it possible to compare the results of tests on similar products nor to compare the results of one test with those of other tests.

At the present time, we are forced to use our own testing procedures on innumerable items in the absence of recognized test procedures. I think you will be interested in knowing that a survey covering the thousands of items of merchandise tested in our Mechanical Division in the last four years revealed that we were able to examine only approximately 15 per cent of them by standard procedures. This situation exists in a division which utilizes the many test codes sponsored by such organizations as the American Society of Refrigerating Engineers, The American Gas Association, and The American Society of Heating and Ventilating Engineers. The percentage is even lower in other divisions. For instance, as probably most of you know, in the textile field, A.S.T.M. and the American Association of Textile Chemists and Colorists have developed many procedures for evaluating textile fibers and fabrics, but procedures for examining fabricated apparel or household goods are practically nonexistent.

The formulation of satisfactory evaluation methods covering consumer merchandise is a complicated problem. The first step is determining what factors have real significance in ascertaining the suitability of merchandise for end point use. The second step, finding adequate, quantitative means for measuring significant factors, is, if anything, more complicated than the first. It involves not only practical and scientific skill and knowledge, but often the performance of hundreds of verification tests to correlate laboratory tests with use tests.

The examples presented here I think will clearly indicate the need for work to be done on the development of standard test procedures for consumer goods. Figure 1 shows a portion of our Textile Laboratory where tests are being made to determine the fastness of fabrics to light. The Fade-o-meter is standard equipment which has been in use in testing laboratories for many years; yet, to date, the method for determining the fastness-to-light of textiles, sponsored by the American Association of Textile Chemists and Colorists, is a tentative method that has not been adopted as official.

Figure 2 shows another piece of more or less standard laboratory equipment, "The Taber Abraser," used in making abrasion tests on many types of materials. This is a device that has been in use for some time; yet, at present, neither the machine nor methods involving its use have any widespread acceptance throughout industry.

With this situation existing in the status of machines and methods used in appraising materials, it is not surprising to find that the surface has just been scratched in establishing standardized testing procedures for fabricated items of merchandise.

How Sears Test Various Items of Consumer Goods

The remainder of the examples will, I believe, illustrate the enormous amount of work it has been essential for us to do in order to obtain any factual information concerning many of the hundreds of items of merchandise which we handle.

Wallpaper:

Figure 3 is a picture of the machine which we use in investigating the washability of wallpaper. This machine was designed by the United Wallpaper Factories, and we have been using it in our Chemical Laboratory since 1939.

In 1940 and 1941, the Wallpaper Institute carried out considerable research on washability and finally recommended that this machine be adopted as standard and proposed that a method for its use be incorporated in Commercial Standard CS 16-29. However, the work was stopped by the war and, to

Fig. 1.—Testing Apparatus for Determining the Fastness of Fabrics to Light.

Fig. 2.—The Taber Abraser.

date, no official action has been taken.

Our machine is equipped with a 4-lb. weight which has its washing area covered with a thick sponge rubber pad and a clean white surgical bandage. It is hand operated at a speed of 75 to 100 rpm. Samples of suitable size are cut from each run of washable wallpaper and subjected to rubbing with a neutral soap solution under the 4-lb. weight. All plain papers must withstand 50 rubs and all embossed papers 25 rubs in order to meet our requirements. These requirements are much more severe than those recommended by the Wallpaper Institute. We do not believe that those requirements would be sufficiently rigid to insure satisfactory washability. The Institute proposed using a 4-lb. weight on plain papers and a 2-lb. weight on embossed papers and requiring each to withstand 25 rubs. Also, all samples would be mounted firmly to wallboard while our samples are not mounted but are placed on a porcelain or glass surface, thus making the test more severe due to increased friction.

In examining a sample of wallpaper, we test at least two, preferably three, surface areas across the sample in order to detect faulty or nonuniform coating. Occasionally we have found samples which withstand 100 rubs or more with no breakdown on one side of the strip, whereas the opposite side has broken down in 3 or 4 rubs. Work is now in progress on a new machine that involves rubbing across the entire area of a strip of paper in order to check more carefully on lack of uniformity.

Vacuum Cleaners:

Vacuum cleaners afford an excellent example of the situation we encounter in attempting to obtain a complete picture of the serviceability of many items of consumer goods. When we started testing vacuum cleaners in our laboratory we found several standard testing procedures that could be used in evaluating some one function or characteristic of the cleaner, but we found it essential to work out for ourselves the step-by-step procedure for examining the item as a unit.

Tests are conducted on vacuum cleaners by the Electrical Laboratory assisted by the Home Economics Laboratory and often by several of the other divisions. In evaluating a vacuum cleaner we want to determine its ability to remove dirt and investigate its electrical safety, its dependability, and life characteristics.

The work is started in the Home Economics Laboratory where dirt pick-up tests on naturally soiled rugs are conducted, comparing the efficiency of the test cleaner with a standard cleaner. Ease-of-operation tests are also conducted at this time, primarily to rate the cleaner as to the amount of effort required on the part of the operator.

Illustrated in Fig. 4 is the major engineering test conducted on a vacuum cleaner. This test is devised to determine the suction-air movement characteristics of the cleaner. The apparatus used is the so-called "government box," built according to specifications of the National Bureau of Standards. The box is hollow and is airtight except for the variable intake orifice. Connected to the box is a water-column manometer. Orifice size is varied from zero to 1½ in. in diameter and suction is measured under each condition. Then by calculation, the cubic feet per minute of air movement for each test condition is determined. Results are presented graphically.

While the cleaner is still installed on the test box, the motor temperature rise is measured. If the temperature goes too high, there is danger that the motor will overheat and damage its windings or bearings.

Fig. 3.—Machine for Determining the Washability of Wallpaper.

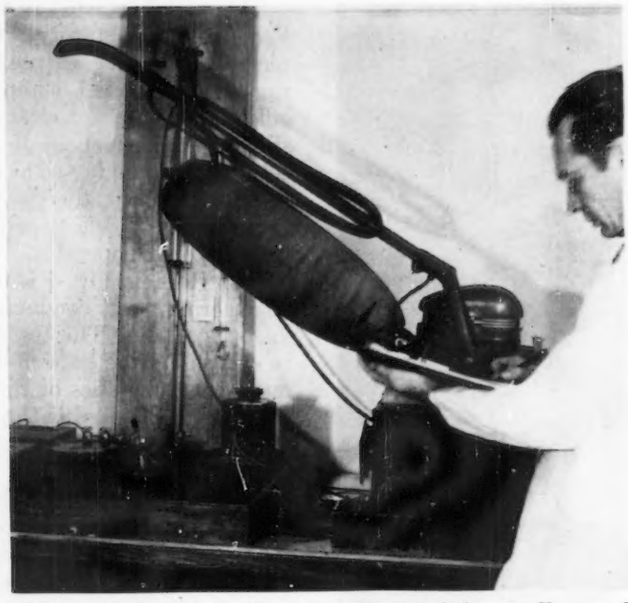

Fig. 4.—Testing the Suction-Air Movement Characteristics of a Vacuum Cleaner.

Other tests conducted include: (1) current leakage and dielectric strength tests made to ascertain that the cleaner is electrically safe to use; (2) noise tests; (3) life tests on the motor and its carbon brushes, the revolving brush, the rubber belt, and the switch; and (3) an evaluation of the bag material with regard to dust retention and free air passage. This last-named test is made in the Textile Laboratory, using Sears' developed apparatus and test procedures. Finally, the vacuum cleaner is studied from the standpoint of quality, sturdiness of construction, and ease of servicing.

Warmth Testing:

The protection furnished against cold by blankets, coats, and other outer apparel is an important consideration to the consumer. While considerable work has been done on this problem by the National Bureau of Standards, there were no warmth testers manufactured for sale at the time that we made our device (Fig. 5).

In studying the problem we found that the National Bureau of Standards machine used a small test area and required that the merchandise be cut. In building our machine we wanted to be able to use a larger test area so as to minimize the effects of thickness or unevenness of fabric construction. We also wanted to be able to make tests without having to cut the blanket, coat, snow suit, or other item of merchandise which we were examining. In using this machine we obtain a thermal conductivity factor which can be used at the present time only as a measure of comparative warmth of various fabrics, due to the limited experience available in measuring this characteristic and correlating it with desirable thermal properties.

Frozen Food Packaging Materials:

In our Home Economics Laboratory, we make a very special effort to judge merchandise from the standpoint of the housewife. We did a great deal of work in this division that was instrumental in determining the final design of our home freezer that was recently placed on the market. However, in Fig. 6, we were not working on the freezer, but were testing packaging materials for frozen foods.

Frozen food packaging is tested not only as a material but also as a household item. Packages are filled with cut and whole vegetables, fruits in syrup, and ground meat—frozen and stored. The technician evaluates the package from the following standpoints:

1. Ease of filling with dry and liquid foods.
2. Liquid tightness of the package.
3. Speed of freezing of food in carton, and amount of surface in contact with prime surface.
4. Ease of labeling of carton.
5. Provision for sealing carton.
6. Does the carton hold its shape when filled so that it can be easily stacked?
7. The shape of the carton for economical use of freezer space.
8. The size of carton in relation to number of servings needed for a family.

In addition to these features, consideration is also given to space occupied by the carton for shipping and the method of folding as related to possible causes of bulging and ease of setting up for use.

Moisture-vapor-transmission tests are made on liners for cartons and

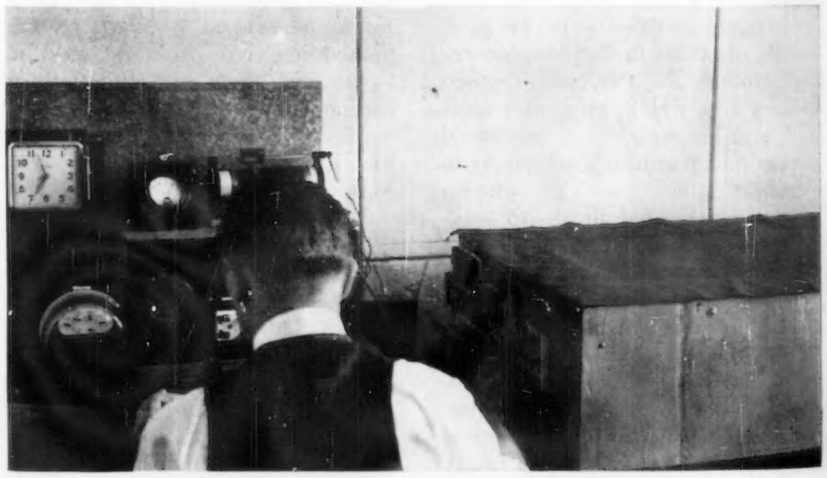

Fig. 5.—Device for Testing the Warmth of Wearing Apparel.

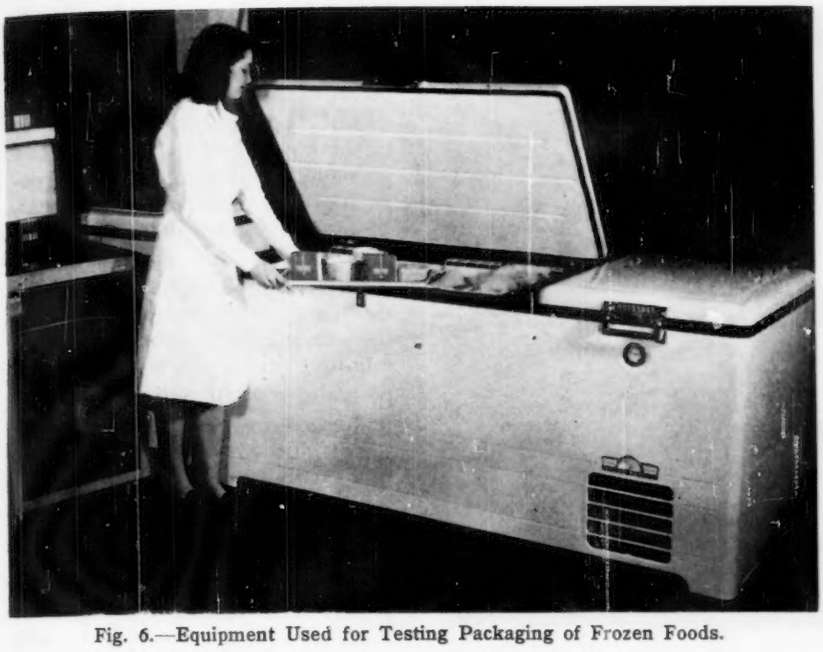

Fig. 6.—Equipment Used for Testing Packaging of Frozen Foods.

they are also tested for effectiveness of seal and design for fitting the box to give maximum capacity within the box.

After three months' storage, the packages are removed from the freezer and examined for damage due to frost and handling. The food is removed and examined for indications of desiccation and finally prepared for the table. Judges score the food on the basis of color, flavor, and texture.

Finishes for Table Tops:

Figure 7 illustrates an interesting case in which we had to develop our own procedures and requirements due to the particular finish desired for a table top. Bright red is a very popular color at the present time in kitchen furniture and appliances. Most manufacturers employ cadmium red pigments to achieve this colorful, heat-resistant, and highly durable finish for tables. Due to the potential toxicity of cadmium and its salts, we do not permit their use in any of our merchandise which may involve even a casual contact with food. We have adopted this policy both for our own protection and the protection of our customers. We insist that our sources employ a substitute coating without sacrificing any of the desirable properties of the cadmium coatings. Consequently, this is one type of merchandise on which we run complete paint composition determinations, in order to check for the presence of cadmium or other toxic pigments and also for the presence of toxic vehicles.

To verify whether or not permissible coatings or finishes for table tops meet durability requirements, we have evolved the extremely severe heat-resistance test pictured here. We employ two electric irons, one of which is heated to 300 F., the other to 500 F. Both irons are placed on the flat finished surface and allowed to remain for 1 min. The irons are removed, the surface allowed to cool, and examined for any breakdown, such as discoloration, peeling, blistering, and softening of the paint film. The test is then repeated allowing the irons to remain in contact with the surface for 5 min. before removal and examination. While this test is not objective, the use of the two different temperatures and times permits us to grade varying degrees of resistance. A finish which will withstand a temperature of 500 F. for 5 min., showing no effects whatsoever, is rated excellent—others are down graded accordingly.

Elastic Fabrics:

Elastic webbing made of square-cut rubber has been important in garters and suspenders for many years. With the development of extruded rubber yarns and two-way stretch fabrics, the uses to which

Fig. 7.—Method of Testing the Durability of Table Finishes.

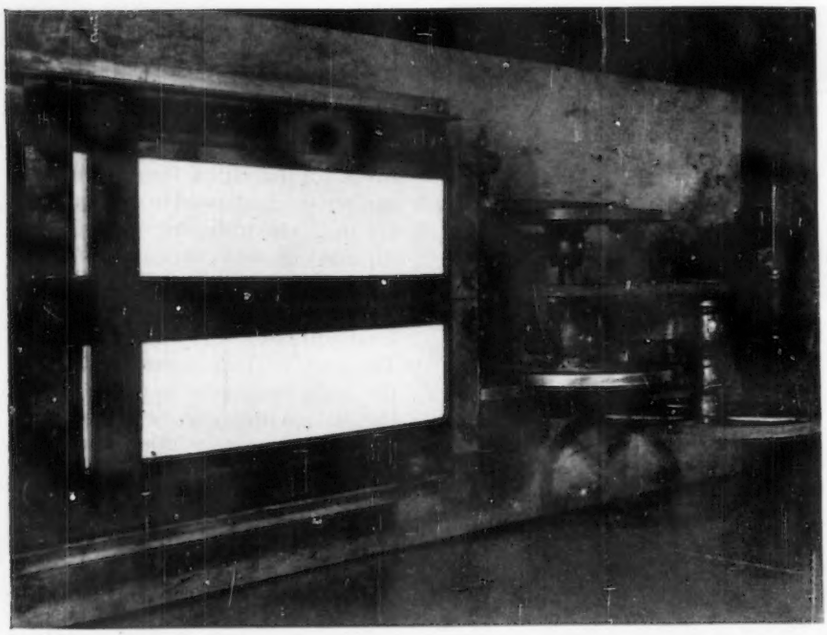

Fig. 8.—Stretch Tester for Testing Elastic Fabrics.

elastic fabrics were put greatly increased in such items as corsets, girdles, bathing suits, and shoes.

In connection with this increased use, the problem of evaluating various constructions of elastic fabrics arose. In our laboratory we searched for published test procedures and, in this case, found no established procedures even on the material, and once again found it essential to develop our own.

One machine which we built to test elastic fabrics is illustrated in Fig. 8. We call it a stretch tester because the elastic fabric is stretched and then allowed to relax. The machine operates at 100 rpm., thus the fabric is stretched and released 100 times each minute. The fabric can be stretched any predetermined amount up to its elastic limit, but we normally stretch to 80 per cent of the elastic limit. We observe any failure of the elastic yarn and if the yarns do not fail we measure the resistance to stretch of the fabric before and after 50,000 stretch cycles as well as measuring any permanent set.

We make a stretch test on the original fabric as received, and also after washing, and after aging in an air bomb.

In the change-over from natural to synthetic rubber, we found this machine of great assistance in evaluating the various elastic fabrics that were submitted.

Farm Wagons:

The testing of farm wagons, of the box type, is accomplished by placing the wagon box in a special bolster set. The bolster at one end of the box is stationary, and the bolster at the other end is pivoted at its center. By means of a suitable gear mechanism and motor drive, the front bolster is oscillated about its center at a rate of 30 cycles per minute, thus applying racking stress to the wagon box. The wagon box is loaded to its rated weight capacity with anthracite buckwheat, which has approximately the same bulk density and size as shelled corn. After determining that it will carry this load satisfactorily, the racking test is continued until failure occurs at the seams, or other points of construction of the wagon box.

We have found from experience that farm equipment is a line of merchandise that is exceedingly difficult to evaluate. Sears maintains two experimental farms, the facilities of which are utilized for actual field testing of wagons as well as other farm implements, both tillage and nontillage types. In this manner we correlate laboratory tests with use tests and also the knowledge we gain from field testing enables us to devise more significant laboratory procedures.

Ironing Boards:

Ironing boards are a standard household item which seemingly could be judged without setting up an elaborate procedure; yet the

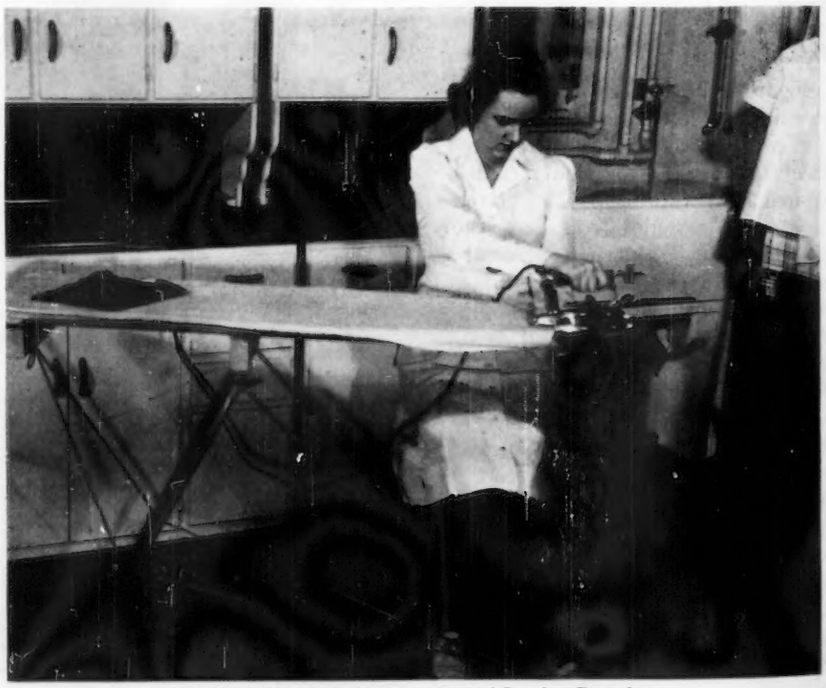

Fig. 9.—Actual Service Testing of Ironing Boards.

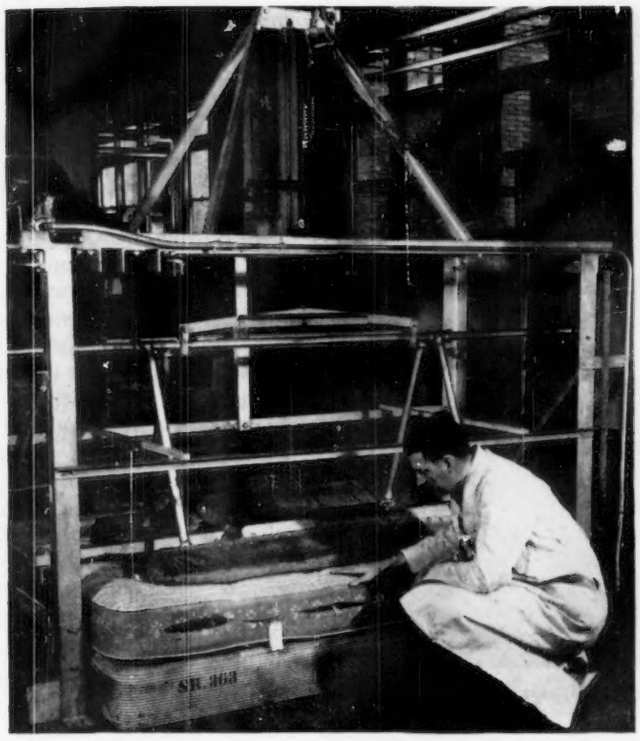

Fig. 10.—Machine Designed for Testing Mattresses and Bed Springs.

number of factors entering into making an ironing board a satisfactory piece of equipment is rather astounding.

The features which we evaluate in our procedure are: (1) weight, (2) spread of legs, (3) ease of opening and closing, (4) rigidity and tendency to skid on the floor, (5) flatness of top, (6) storage space required and provision for hanging, (7) ease of attaching cover, and (8) height, suitable for sitting or standing, as judged by women of different sizes.

In our tests (Fig. 9) we iron garments, such as lingerie, sheets, and infants' wear, that would be found in the typical family laundry. While ironing, attention is given to such points as skirt clearance under the board. The rapidity with which garments can be ironed is noted. Infants' clothing affords an opportunity to examine the shape of the board, particularly the narrow end, for ease of use.

The appearance on the market of boards with perforated tops necessitated our adding special tests for this type of board. Presumably, these speed up ironing by allowing moisture to pass through the pad more quickly. Consequently, we conduct a test in which the pad is weighed before and after a given amount of ironing, on a perforated board, and compared with a pad used on a standard wood ironing board.

Mattresses:

A mattress is an excellent example of merchandise that must be tested as a unit rather than by testing its component parts. For instance, we could take a mattress and determine the quality and sturdiness of the ticking, evaluate the filling and the spring material and construction, and still know nothing about how quickly that mattress would fail in service. A mattress, like many other items of consumer goods, is only as strong as its weakest component, whether that component is a material or a seam, or other construction device holding it together. Consequently, we designed the machine shown in Fig. 10 for testing mattresses and bed springs. In testing a mattress, the sample is placed upon a bed spring of standard construction, and in testing a bed spring, the sample is placed beneath a mattress of standard construction. This enables us to simulate actual use conditions as closely as possible. The weight-applying mechanism, which oscillates upon the sample under test, rests freely upon the sample and is oscillated at a rate of 30 cycles per minute. The entire weight of the reciprocating mechanism is 310 lb.

A reference point is used to determine the initial thickness of the mattress, or spring, and readings of the occurrence of permanent set

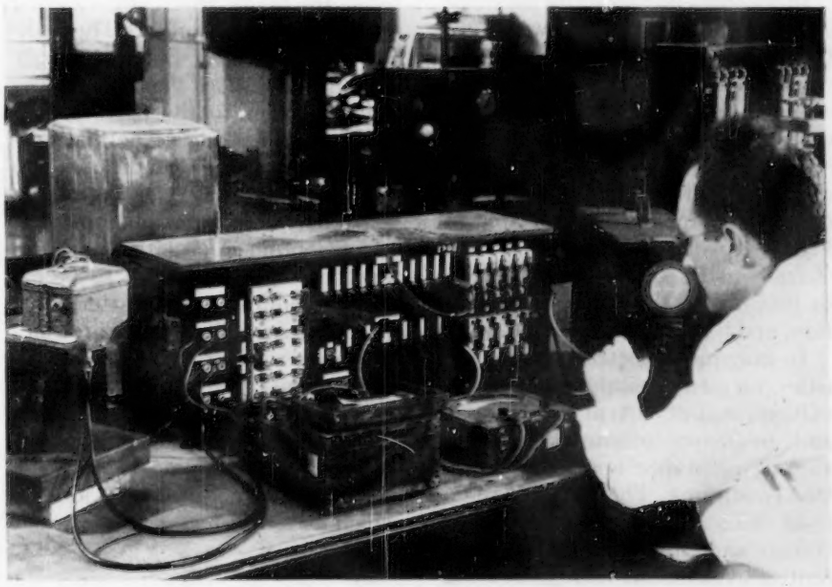

Fig. 11.—Apparatus Used to Determine the Electrical Characteristics of Fence Controllers.

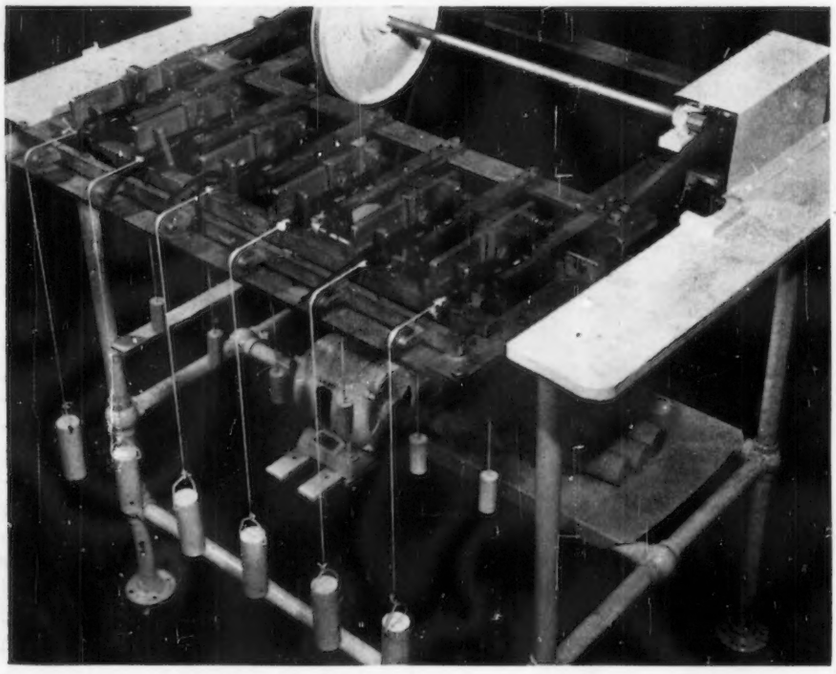

Fig. 12.—Machine Designed for Testing Zippers.

are taken at the end of every ten thousand cycles of operation. A good mattress will satisfactorily withstand one hundred thousand cycles of operation on this machine. At the end of the test, mattresses are not only examined for external signs of failure but are cut open and the internal construction examined.

Electric Fence Controllers:

In writing our procedure covering electric fence controllers, we found Underwriters' Laboratories testing methods of great assistance. However, since naturally their primary consideration is safety, their requirements were not sufficient for a complete study of the item. We employ the apparatus illustrated in Fig. 11 to determine the electrical characteristics of fence controllers, to investigate the safety of operation, and the reliability of operation.

In examining electrical characteristics, we measure input current and voltage, output current and voltage, and frequency of impulses under various resistance and capacitance load conditions. The results of these tests indicate whether sufficient voltage and current are available to control livestock without presenting shock hazard.

If the controller is of the "high line" type, operating from a 110-v., 60-cycle source, safety investigations are made to be assured that it is not possible for line current and voltage to be impressed on the fence line, either under normal or abnormal conditions, including possible failure of parts.

Dielectric strength tests are conducted to determine the ability of the insulation to withstand electrical surges, and current leakage tests are made from any exposed metal parts to grounds. The leakage test reveals the presence of any uncontrolled shock hazards of potential danger to the user.

Normal life tests at normal outside atmospheric conditions are used to show any weak spots in controller design or manufacture, and to obtain information concerning the length of service to be expected from one set of batteries.

Accelerated life tests are employed as a faster means of obtaining general results on mechanical parts. In addition, this is an item of merchandise which we field test in order to determine that it will satisfactorily perform the job for which it is intended.

Zippers:

Zippers illustrate a small item of merchandise that plays a very important part in customer satisfaction with various consumer goods, particularly in clothing items.

We are very little concerned with the material from which they are made, providing they will not corrode, warp, discolor, stain, or fail in any other way under conditions of wear, washing, and ironing.

The machine shown in Fig. 12 was especially designed for use in our zipper testing procedure. In operation, the zipper is mounted on a horizontal plane with a 1-lb. tensile load applied longitudinally and a transverse load of $\frac{1}{2}$ lb. The crank mechanism of the machine is connected to the zipper slider which is actuated through a 3-in. stroke at a rate of 48 cycles per minute. A good zipper will withstand ten to twenty thousand cycles of this type of operation without showing any tendency to warp or pull apart.

Bed Sheets:

Finally, I should like to discuss with you problems encountered in attempting to obtain information about the serviceability of bed sheets. Bed sheets are consumer goods that have been on the market as a staple item for many years. In bed sheets, as in almost no other textile item, serviceability is of prime importance while style considerations are practically nil. It would seem logical to expect that this would be one class of merchandise for which a complete test procedure would be available. Not only is this not the case, but at the present time, very little is known about the factors which contribute to serviceability, and practically nothing about means for measuring these factors.

For instance, we would very much like to know the relative importance of fabric construction as contrasted to cotton quality in contributing to serviceability. We have made hundreds of tests ourselves and have examined all the results of tests made by others that we could locate, and we still do not know the answer. In the past, this question has been approached from many different angles. Actual use tests have been made that have furnished valuable data, but these tests took

from 5 to 7 yr. to complete, and the constructions and qualities covered were necessarily limited.

Evaluation of sheets in the laboratory has been based largely on the breaking strength of the new fabric or on breaking strengths of the fabric after repeated laundering. However, actual use tests have shown that the sheet fabric that is strongest to start with does not always remain the strongest as a result of use.

A study of the reports on use tests indicates that some of the factors that influence serviceability are: abrasion, flexing, perspiration, and laundering, and that it would be desirable to attempt to devise a test cycle that would combine measuring each of these factors.

This brings us to the problem of measuring means. For instance, an abrasion machine, such as the Taber, shown in Fig. 2, is a useful instrument but it has its limitations. Once the test specimen is removed from the turntable it cannot be replaced for further testing. Consequently, any test cycle combining abrasion with laundering would require the use of a different type of machine. Also, since the breaking strength of a worn fabric is probably a good criterion of destruction incurred, it is desirable to have an area abraded and washed that is large enough to test for breaking strength.

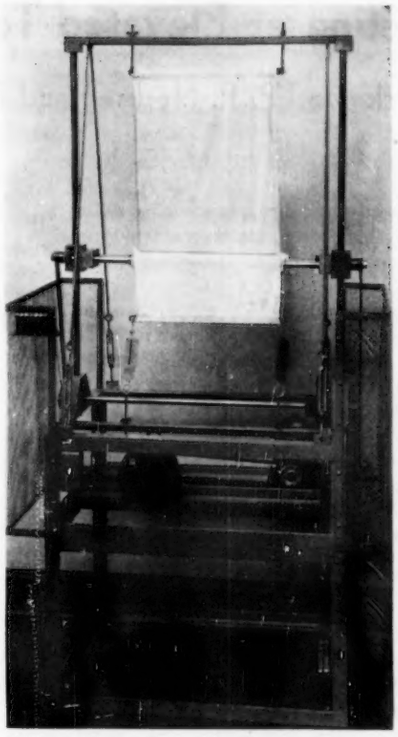

Fig. 13.—Machine that Combines Abrasion with Laundering for Testing of Bed Sheets.

With these points in mind we built the machine illustrated in Fig. 13. We show this machine not because we have solved our problem, but because there is a problem requiring a solution.

I should like to explain the machine briefly. The test specimen can be abraded and flexed at the same time. It can be removed for immersion in perspiration solution and for laundering and later returned for another abrasion and flexing cycle. The cycle can be repeated as many times as necessary.

I shall mention just a few of the things that we do not know about this machine as yet. We do not know what would be the most suitable abrasive for the rollers being used; we do not know the optimum number of abrasive rubs per cycle; we have not succeeded in working out a desirable laundry procedure; and we know nothing about the results we obtain as compared with actual use.

Need for Standard Test Procedures

In conclusion, I do not believe that anyone would be foolish enough to say that standards are not needed for ultimate consumer goods. However, it is one thing to ask for standards, and quite another to set them up intelligently and practically. Possibly some day or year in the future, we shall be ready for consumer standards, but I believe this will come only when we have set up proper test procedures that can be instrumental in establishing consumer standards.

A.R.E.A. Committee Chairmen

Because of the interest of many A.S.T.M. members in the work of the American Railway Engineering Association we publish below a list of Chairmen and Vice-Chairmen of several of the A.R.E.A. Committees. A recent rule has been established which limits the tenure of office of the Committee Chairmen and this has resulted in many new appointments.

Committee	Chairman	Vice-Chairman
Ties	C. D. Turley, Illinois Central Railroad Co.	F. G. Campbell, Elliott, Joliet & Eastern Railway Co.
Rail	C. B. Bronson, New York Central System	*C. B. Bryant, Southern Railway System
Buildings	C. H. Lorenz, Cleveland, Cincinnati, Chicago & St. Louis Railway	W. G. Harding, Missouri Pacific Lines
Masonry	F. R. Smith, Union Railroad Co.	C. B. Porter, Chesapeake & Ohio Railway Co.
Water Service	E. M. Grime, Northern Pacific Railway Co.	H. F. King, Erie Railroad Co.
Iron and Steel Structures	E. S. Birkenwald, Central Lines, of Southern Railway System	R. W. Mabe, Nashville, Chattanooga & St. Louis Railway
Wood Preservation	C. S. Burt, Illinois Central Railroad Co.	W. R. Goodwin, Minneapolis, St. Paul & Sault Ste. Marie Railway
Maintenance of Way Work Equipment	Edgar Bennett, Central Lines of Southern Railway System	R. K. Johnson, Chesapeake & Ohio Railway Co.
Waterproofing	G. E. Robinson, New York Central System	C. A. Whipple, Chesapeake & Ohio Railway Co.

* Resigns May 31, 1946

Scientific and Specialized Personnel

Information on the National Roster of Scientific and Specialized Personnel, which was established to aid in wartime demands for trained professional men and women, indicates that as of the end of 1945 there were about 397,000 people registered. Of this number some 200,000 were in the engineering fields, with the mechanicals, civils, electricals, and chemicals running about 54,000, 47,000, 40,000, and 24,000, respectively, and with other fields about 34,000. In the so-called physical sciences there were close to 90,000 noted, with chemistry far in the lead with about 62,000 and mathematics and physics groups close to 10,000 each.

The Roster aided greatly in connection with some special problems, and now functions as a Division of the United States Employment Service in the Department of Labor.

Tension Testing at Elevated Temperatures

By T. M. Blackmon,[1] P. R. Nourse,[2] and E. H. Plesset[1]

SYNOPSIS

A simple and inexpensive method of heating tension specimens by resistance heating, a method of measuring specimen temperatures, and two types of extensometers and the associated electronic equipment for use with a Baldwin-Southwark recorder, have been developed. One extensometer is a reworked compressometer for use in the elastic range. The other extensometer measures elongations up to 50 per cent of a 2-in. gage length for studies in the plastic range. The tension specimen may be broken without damaging the latter extensometer. The calibrating adjustments have been set so that 50 per cent elongation results in a 10-in. record (of the elongation) on a Baldwin-Southwark tension machine recorder; the elastic range is necessarily so foreshortened that it is not discernible on the record.

In addition, a technique has been established for determining the true load at fracture of ductile specimens; the customary procedure of visually noting the load when the fracture "snap" is heard may lead to errors of 50 per cent in judgment of the load.

THE heating of tension specimens for the purpose of studying their elongation characteristics at elevated temperatures may be accomplished by various methods. Several of the heating methods are: (1) radiation; (2) electromagnetic induction; (3) incorporation of an oven around the tension specimen, and (4) electrical resistance, in which current is passed through the specimen. The last method has been used because of its convenience and simplicity. It has, furthermore, yielded uniformly satisfactory results.

Since, if resistance heating is used, the sample is exposed and accessible, its temperature may be measured with a contact thermocouple, provided the couple junctions and wires are small and have low thermal conductivity and capacity.

To record the stress-strain characteristics of materials having high percentages of elongation, a relatively insensitive extensometer is needed. For this purpose, an extensometer was developed which is basically an electrical potentiometer mechanically coupled in a 1:1 ratio to the sample.

Tests conducted at room temperature indicated that loads at fracture may be determined with reasonable accuracy by noting the load scale reading at the time of snap, provided that specimens of low ductility such as 24S-TAL, 75S-T, and 75S-TAL are used. Specimens in the 0 condition, or those which are at a high temperature, are, however, comparatively ductile and the simple procedure may lead to serious inaccuracy. Adequate accuracy (assigned probable error of ±3 per cent) has been achieved by recording the dynamic reading of a strain gage load ring which was inserted in series with the testing machine and tension specimen.

MEASUREMENT OF SPECIMEN TEMPERATURE

Special contact thermocouples were made for measuring the surface temperature. As detailed in

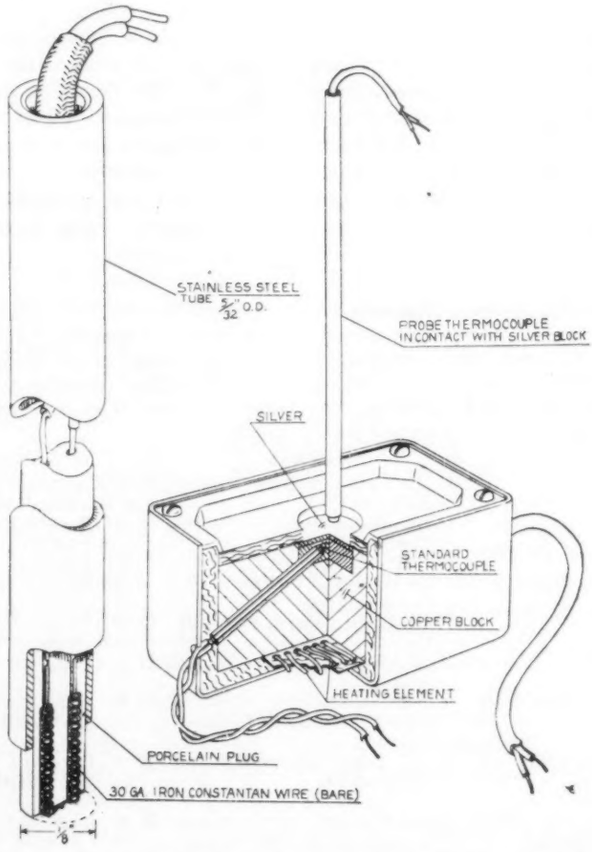

Fig. 1.—Method of Construction of Low Thermal Capacity Contact Thermocouple.

Fig. 2.—Method of Calibrating Contact Thermocouple.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Member and Supervisor, respectively, Electrical Laboratory, Douglas Research Laboratories, Douglas Aircraft Co., Inc., Santa Monica, Calif.

[2] Formerly of Electrical Laboratory, Douglas Research Laboratories, Douglas Aircraft Company, Inc., Santa Monica, Calif.

Fig. 1, the No. 30-gage iron and constantan wires were installed in a $\frac{1}{8}$-in. diameter porcelain tube. The junction at the end of the tube is electrically welded. The leads through the small holes in the porcelain tube were coiled to provide a mechanical cushion for the couple and to reduce heat transfer.

The use of small couples is essential for accurate measurement of the temperature of samples of low thermal capacity like tension coupons. When the temperature of a sample is measured with a commercial contact thermocouple instrument, a lower value is observed than that obtained with a small contact couple. In fact, if such a commercial instrument be placed upon a specimen and a small couple quickly substituted, the temperature is found to rise rapidly to a value higher than that previously indicated. The computed thermal capacity of the contact couple shown in Fig. 1 is small enough so that the error due to heat absorption is negligible. The contact couples were calibrated as shown in Fig. 2 by measuring the surface temperature of a silver block in which a standard thermocouple was inserted.

Due to the high conductivity and low radiation emissivity of aluminum alloys, no significant thermal gradient exists between the core and surface of a heated sample of any thickness up to $\frac{1}{4}$-in. at a temperature of 900 F., despite the fact that no radiation or convection shields are employed, a fact which was checked experimentally as shown in Fig. 3 by simulating the actual conditions. Two $\frac{1}{8}$-in. specimens were cleaned and spotwelded together with a small couple laid between the two adjacent interface surfaces. Each strip thus served as a radiation and convection shield for the other. The two strips were heated by 50-cycle alternating current; the temperature indication of the inner thermocouple was compared to that given by the surface contact couple.[3] As the temperature rose from ambient to 900 F., no significant temperature difference was found. A difference of 1 F. could have been observed with some certainty. When, however, the surface was artificially blackened, a 5 F. differential was observed at 640 F.

The effect of thicknesses greater than $\frac{1}{4}$ in. has not been tested.

Heating of Specimen

In a series electrical circuit, the conduction of current is always accompanied by generation of heat; since the amount of heat so generated per unit length of conductor is proportional to the resistance per unit length of conductor, electrical heating will be largely localized in the regions of the conductor having the smallest effective cross-section. Accordingly, if current leads to a tension specimen are sufficiently heavy, heating may be well localized in the specimen. It is, however, necessary to use an unconventional tension strip shape. The dimensions of the test strips and typical gradients encountered are shown in Fig. 4. Over a 2-in. gage length, the temperature is uniform to better than 5 F. at 500 F. As a result, thermal insulation between the specimen and the testing machine was not considered necessary. Despite the fact that the taper is slight, being only one half the standard value, all specimens have broken at the middle.

Comparative measurements of the resistance of tension specimens $\frac{1}{8}$-in. thick, and of the jaw-to-jaw resistance of the Baldwin-Southwark tension machine, have shown that the current drawn through the shunt formed by the framework of the tension machine is negligible, and that current may be passed through the tension specimen for heating without the necessity of electrically insulating the sample

[3] The holes through which the thermocouple leads are brought must be small in comparison to the cross-section of the sample in order that the resistance per unit length not be increased significantly with a consequent formation of a local hot spot when current flows.

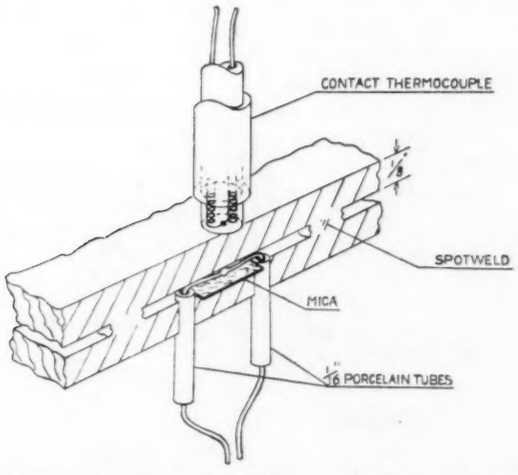

Fig. 3.—Method of Comparing Surface and Core-Temperature Readings.

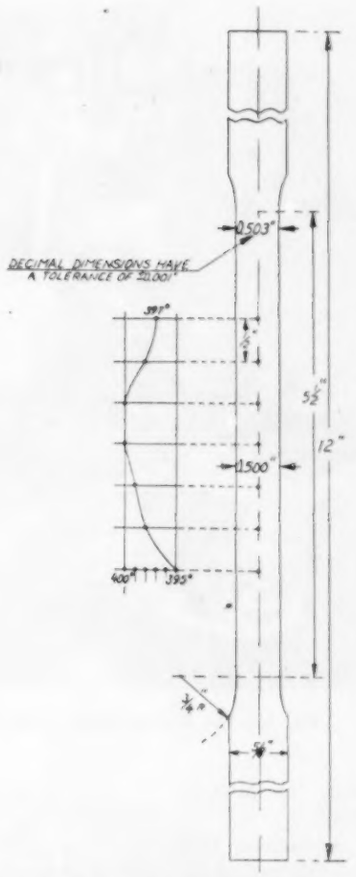

Fig. 4.—Shape of Tension Specimens and Temperature Gradients Encountered in Use.

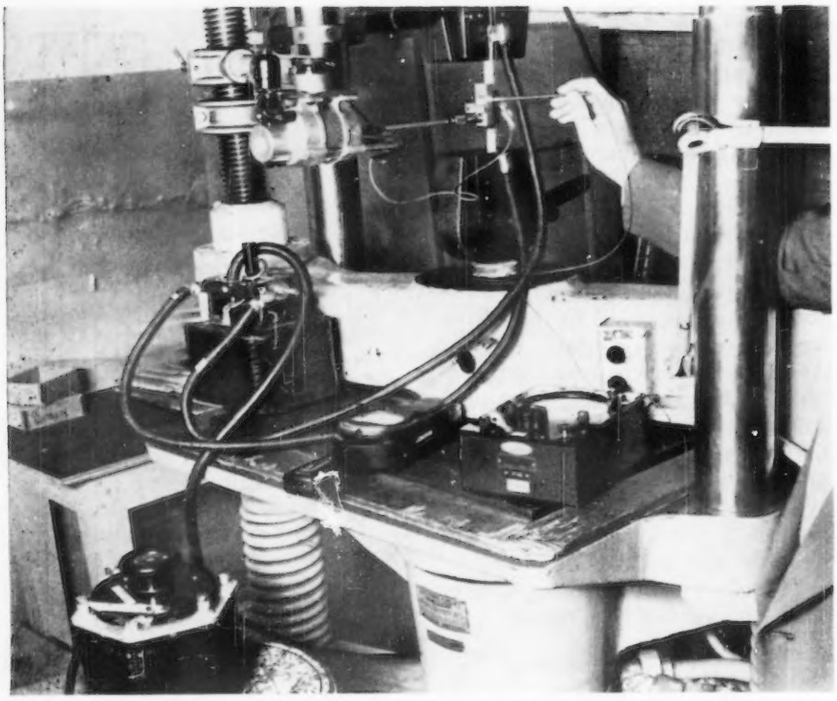

Fig. 5.—The Elastic Range Extensometer and Contact Thermocouple in Use.

from the jaws of the tension machine.

A current transformer of 1-kw. welding rating was used as a source of power. Short leads of insulated No. 00 copper cable, terminating in flat lugs and clamped in the jaws with the ends of the tension specimen, completed the circuit. The input to the current transformer was controlled by a Powerstat in the 110-v. line.

Figure 5 shows the heating setup. The currents required to achieve given temperatures are tabulated below. About one minute is required to bring the specimen to equilibrium temperature. Maximum shunt current through the tension machine is 20 amp.

Temperature, deg. Fahr.	Current, amp.
200	240
300	300
350	335
375	340
400	350
425	360
450	375
475	380
500	400
525	410
550	415

Measurement of Extension

Elastic Range Extensometer:

A type of extensometer marketed by Baldwin-Southwark can be rendered entirely satisfactory by relatively simple modification. The necessary alterations serve to prevent the extensometer from electrically and thermally shunting the specimen. Thin mica sheet and ceramic beads are inserted as indicated in Fig. 6.

The method of operation is the same as that of the Baldwin-Southwark Templin Recorder. A brief description is included here for the sake of completeness. One knife-edge of the extensometer is fixed; the other is hinged. The hinged member carries an electrical contact at the end of a lever, thereby producing considerable mechanical amplification of the knife-edge motion. When, due to rotation of the lever through a small angle, the moving contact engages a fixed contact on the frame of the extensometer, an electrical circuit is completed for the actuation of a motor-driven, micrometer follow-up screw. The recording drum is made to follow by a Selsyn repeater system. The cosine error in gage length arising from rotation of the knife-edge is trivial.

Plastic Range Extensometer:

The method employed for the elastic range extensometer is not applicable to measurements of extension amounting to 1 in. because of the inherent high sensitivity. Accordingly, automatic null potentiometric technique was used. If used in conjunction with a standard

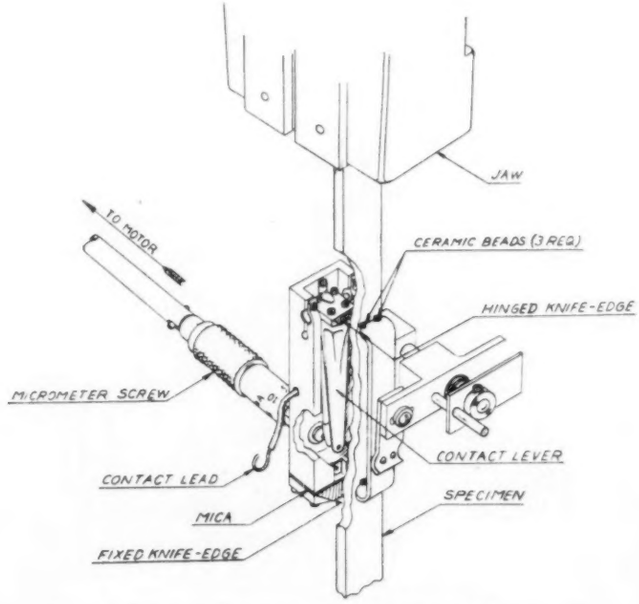

Fig. 6.—Cutaway Drawing of Elastic Range Extensometer.

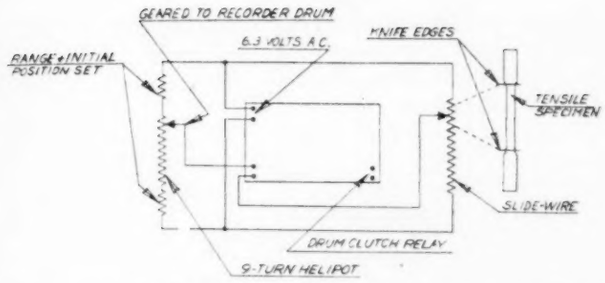

Fig. 7.—Schematic Block Diagram of Slide-Wire Extensometer System.

drum recorder, an ink trace of the extension and the break is obtained.

The plastic range extensometer consists of a framework carrying a a fixed knife-edge and a movable knife-edge with appropriate spring clamps. The movable knife-edge and clamp carries a slide arm which makes continuous contact with a linear slide-wire, which forms one leg of an electrical bridge. The other leg of the bridge consists of a 9-turn potentiometer[4] which is

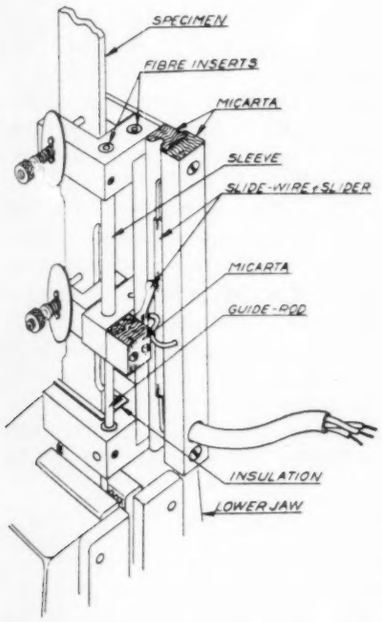

Fig. 8.—Cutaway Drawing of Plastic Range Extensometer.

geared to the recorder drum. The bridge is energized by a 6-v. a-c. source. The difference voltage between the linear slide-wire and potentiometer is applied to the input of an amplifier. When the bridge circuit is unbalanced, that is, when the voltage difference is other than zero, a relay in the output circuit of the amplifier is closed, which in turn actuates the solenoid clutch in the recorder and the drum rotates until the 9-turn potentiometer mechanically coupled to it rebalances the bridge. When the bridge is rebalanced and the difference voltage is zero, the relay opens and the recorder stops rotating. The process is continuous; the drum turns in discrete steps in a similar manner to that described previously for the Selsyn repeater employed with the micrometer follow-up screw. A schematic representation of the method is shown in Fig. 7.

The assembled extensometer is shown in Figs. 8 and 9. The end and movable blocks are made of S.A.E. 1020 steel. The knife-edges are Momax tool steel inserts. The end blocks are fastened with screws to the Inconel back plate. The movable clamp is swiveled at the back center to eliminate motion of the slider due to "orange-peeling" of the specimen. Since, in most cases, the specimen is heated by electrical conduction, the slider guide rods have been fiber-insulated and an insulating lining has been placed in the lower guide block to prevent shunt current passing through the extensometer. The movable clamp is free to extend something over an inch from the initial 2-in. spacing of the knife-edges. To help prevent disturbing thermal effects upon the bridge circuit, a thin corrosion-resistant steel radiation shield was placed between the slide-wire mount and the tension specimen. The slide-wire is a portion of the element of a commercial potentiometer; in the present case, the slide-wire is wound with 294 turns per inch of Ohmax wire. Approximately 2 in. of the winding were used.

The 9-turn, 2000-ohm. helipot rotates eight times for each revolution of the drum. The gear drive assembly may be detached by removing one knurled screw. The method of mounting is shown in Fig. 10. The fixed resistors shown in Fig. 7 are chosen so that 1-in. elongation in a 2-in. gage length results in a record 10 in. long. Any standard high-gain amplifier may be used; the sensitivity should be sufficient to actuate the relay in the output circuit when the bridge is unbalanced by a $\frac{1}{294}$-in. motion (one turn on the slide-wire). The frequency response need cover only a small band containing the 50 to 60-cycle range of commercial power frequencies, since the bridge is conveniently energized by commercial line supply

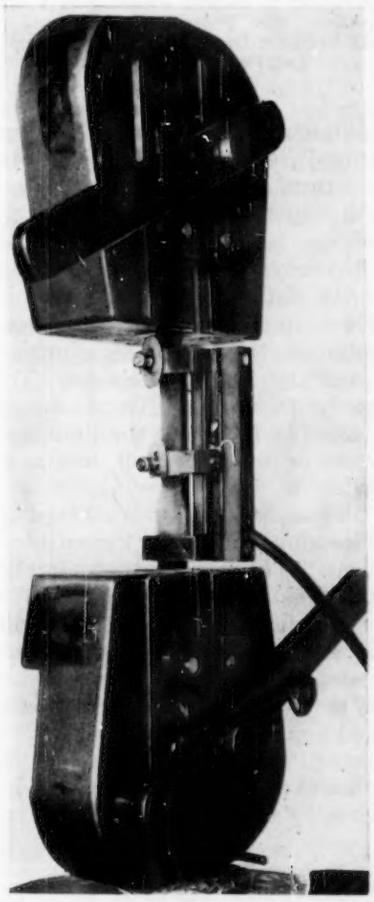

Fig. 9.—Plastic Range Extensometer in Use.

[4] Beckman Helipot, marketed by National Technical Laboratories, South Pasadena, Calif. This potentiometer was chosen because of its relatively high linearity. The resistance of such a unit is an accurate linear function of the angle of rotation, generally within at least ±½ per cent.

current.[5] In the present case, with 6.3 v. a. c. applied to the bridge, the voltage change per turn of slide-wire is $\frac{6.3}{588}$ v. (since a slide-wire of 2 in.

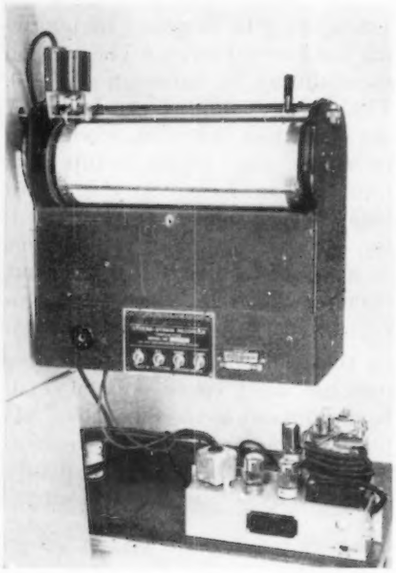

Fig. 10.—The Baldwin Ink Recorder as Modified to Record Plastic Range Extension. The Potentiometer Geared to the Recorder Drum Appears in the Upper Left Portion of the Figure.

containing 294 turns per inch is employed), or approximately 10 mv. per turn. The amplifier employed will trip the output relay reliably with a 50-microvolt input signal. Obviously, then, the limit in sensitivity of the system is one part in 294; in other terms, the 10-in. curve plotted for a 1-in. extension consists of 294 discrete steps. The revolution could, of course, be increased by increasing the number of turns of wire per unit length of slide-wire.

A completed unit was checked by displacing the slider by known increments. The record is shown in Fig. 11. The accuracy of repetition is better than 0.5 per cent, and the linearity is within 1 per cent of full scale. The error due to nonlinearity is systematic, but was not considered serious enough to warrant correction. It is caused in part by the inherent nonlinear character of slide-wires, by slight loading of the bridge

[5] The Brown Instrument Co. amplifier used by them in electronic autobalancing potentiometers may be simply modified for the purpose. When the d-c. to a-c. inverter is removed from the input circuit and the output circuit revised to operate a high impedance relay in the plate circuit, the unit is quite satisfactory.

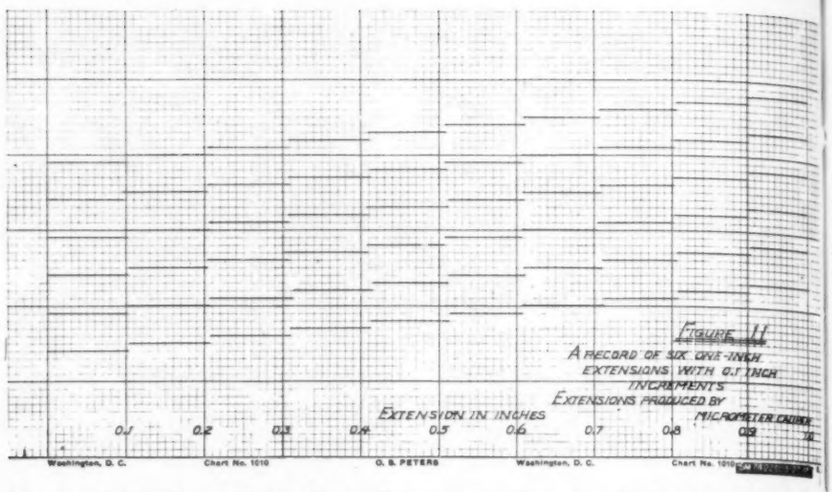

Fig. 11.—Calibration of Plastic Range Extensometer Recorder Made with Micrometer Screw Caliper. The Ordinate Scale Has No Significance.

due to the finite input impedance of the amplifier, and by the stepped, or discontinuous, nature of the voltage from the wound slide-wire. The latter is responsible for random variation in the system. The repetition accuracy quoted above is not the probable error as determined from a large number of trials but is the maximum over-all variation observed in about 20 measurements.

A typical record of the extension of a 3S-O specimen is shown in Fig. 12.

Measurement of Load at Fracture

The investigation described was initiated in order to develop an accurate fracture-load measurement technique to be used in conjunction with a 60,000-lb. Baldwin-Southwark tension machine. A limited number of materials was tested at room temperature. The technique developed is applicable to tension testing at elevated temperatures. Since the conventional method results in serious errors for plastic specimens, it is described here.

For the purpose of the investigation, a basis of comparison was necessary. This was obtained by recording the dynamic load oscillographically. A strain gage load ring was placed in series with the specimen, as indicated schematically in Figs. 13 and 14. The load ring was wired to conventional strain gage carrier amplifier equipment of a type used for flight and laboratory testing.

Forty-eight specimens were sorted according to the expected ultimate strengths, then fractured with the optimum strain gage amplifier sensitivity. The load applied to each

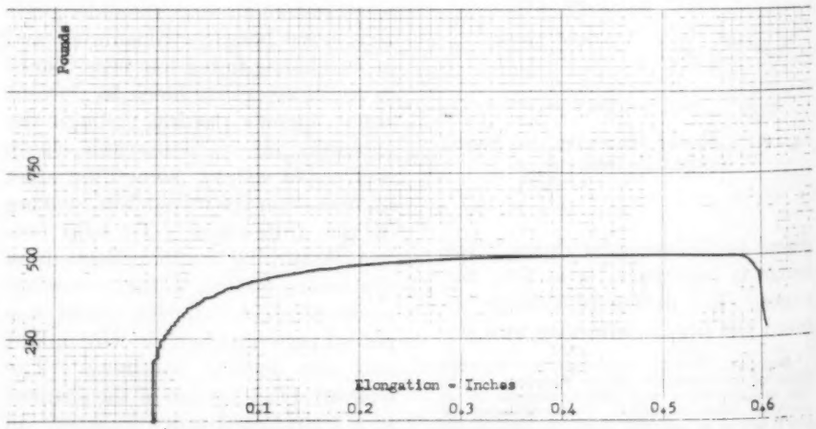

Fig. 12.—Record of Load Versus Extension Obtained with 3S-O Aluminum Specimen.

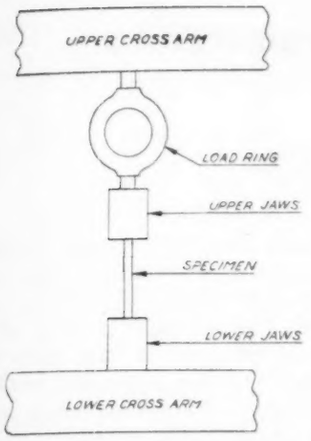

Fig. 13.—Schematic of Mechanical System Used for Measuring Instantaneous Load Values.

specimen was recorded as a function of time by the oscillograph. In addition, the ultimate load indicated by the Baldwin was observed for reference purposes. The fracture load reading was taken at the sound of the fracture "snap." The load ring was calibrated from 0 to 5000 lb. using the Baldwin load scale as the standard.

Comparative results are given in Table I.

The over-all accuracy of the load-ring method is attested by the comparison of the Baldwin scale ultimate load figures with the ultimate load figures obtained from the oscillograph records. These figures agree within 3 per cent. The figures in the table indicate that the fracture-load readings obtained from the Baldwin scale were accurate within 3 per cent for "brittle" materials such as 24S-TAL, XB75S-T, and 75S-TAL. The Baldwin load scale produced a considerable error when ductile materials such as 52S-O and 75S-OAL were fractured. A maximum error of 40 per cent in judgment of fracture load of a 61S-O specimen was noted.

Specimens of low ductility fracture quickly after passing the ultimate load with only little reduction in load; despite the fact that the time rate of load decrease for such specimens may be high, and despite the inertia of the Baldwin weighing system, the load indication is generally reliable even at the time of fracture and the fracture load may be obtained by noting the load scale when the fracture snap is heard. The more ductile specimens suffer a much larger change from ultimate load to fracture load, and even though the period between application of ultimate load and fracture is relatively long, the rate of change of load may be high.

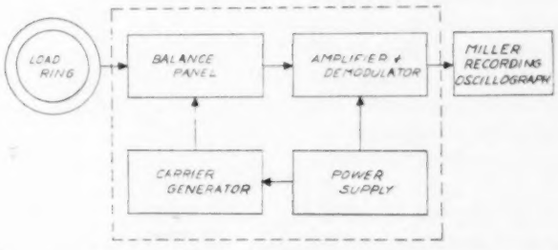

Fig. 14.—Schematic Block Diagram of Electrical System Used for Measuring Instantaneous Load Values.

The mechanical inertia of the weighing system may then be sufficient to introduce serious lag between dial indication and true instantaneous load; a significant portion of the error noted may be due to human error.

On the other hand, the use of strain-gage load-ring technique with oscillograph recording equipment may be counted on to yield an accurate, permanent record of the entire load history of each tension test.

TABLE I.—TYPICAL TENSION SPECIMEN FRACTURE-LOAD DATA.

Material	Baldwin Load Scale			Load Ring Recordings		Slope, lb. per sec.	Specimen	
	Ultimate, psi.	Fracture, psi.	Error,[a] per cent	Ultimate, psi.	Fracture, psi.		Gage	Cross-Section Area, sq. in.
24S-TAL.....	4300	4175	+ 2.0	4400	4100	72	0.125	0.0617
XB75S-TAL...	5120	5050	+ 1.0	5200	5000	297	0.125	0.0635
75S-TAL.....	945	945	+ 1.5	960	930	43	0.025	0.0119
24S-OAL.....	1940	1750	+ 2.5	1890	1710	63	0.125	0.0632
XB75S-OAL...	1880	1750	+ 4.0	1900	1680	134	0.125	0.0622
75S-OAL.....	450	440	+14	450	380	185	0.025	0.0127
61S-O.....	600	280	−40	600	400	191	0.064	0.0320
52S-O.....	865	740	+23	870	570	256	0.064	0.0313

[a] Errors are those in Baldwin load-scale reading. The respective load-ring values are assumed to be correct.

The Application of the Mass Spectrometer to Chemical Analysis

By A. Keith Brewer[1]

In spite of the fact that mass spectrometers were developed some twenty-five years ago, it is only within the past three years that they have been used for the analysis of gas and hydrocarbon mixtures. Their previous use was confined almost exclusively to isotopic analysis. This new application has resulted primarily from the discovery that hydrocarbon molecules, when bombarded by electrons having an energy several times that necessary for ionization, that is, 50 to 100 v., are not only ionized but are dissociated into fragments, the number and relative abundance being the same for any given molecular species (**1,2**).[2]

The mass spectrometer is essentially a momentum analyzer, in that molecular masses having identical energies are deflected into arcs whose radii are proportional to their momenta. The chemical properties *per se* are not involved.

In operation, the molecules to be analyzed are first ionized and dissociated into characteristic fragments by bombardment with a stream of electrons of 50 v. or more. This process is carried out in the gas phase at a pressure of about 10^{-5} mm. of mercury. The ions so formed are then given identical energies in a fixed direction by a potential difference between two slits. The energy is given by $eE = \frac{1}{2} mv^2$ where e is the electronic charge (for singly charged ions), E is the potential in electrostatic units, m is the molecular weight in grams, and v is the velocity in centimeters per second.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] National Bureau of Standards, Washington, D. C.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

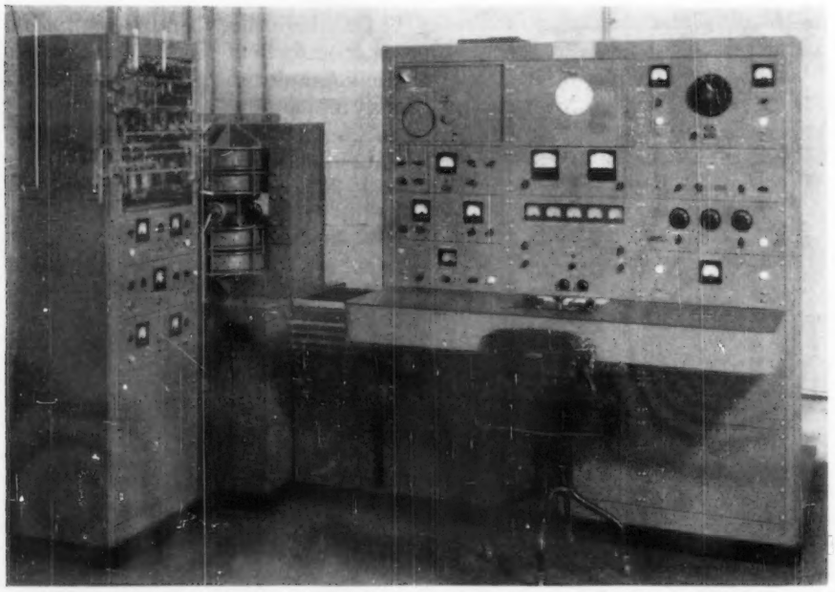

Fig. 1.—Consolidated Mass Spectrometer at the National Bureau of Standards.

The gas inlet system is shown on the left. The electromagnet with the analyzing chamber between the pole pieces is in the center section. The control panel, containing the high voltage power packs and recorder, is on the right.

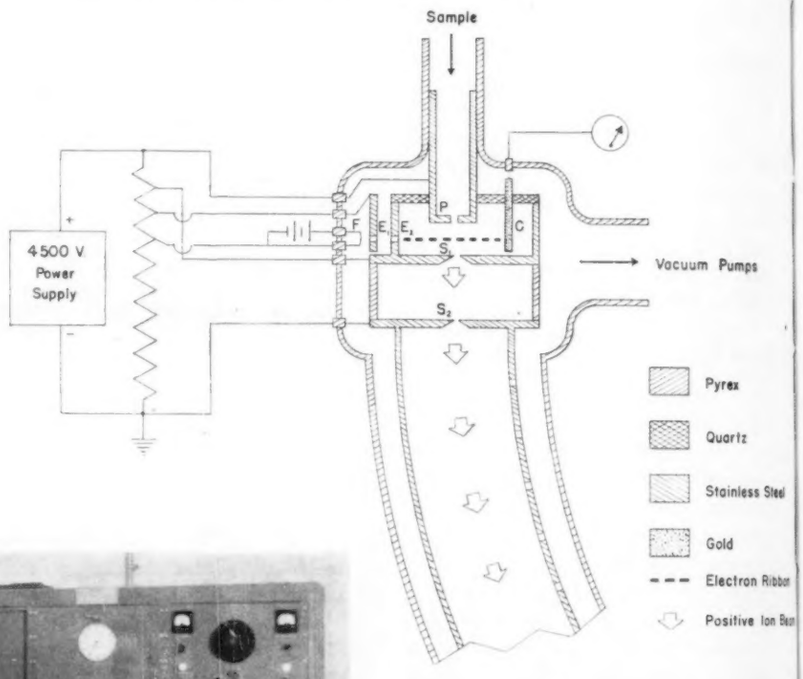

Fig. 2.—Schematic Drawing of the Ionization Chamber.

Molecules entering through the sample inlet are ionized and dissociated into fragments by 50-v. electrons emitted from tungsten filament *F*. The ions formed along the path of the electron beam are brought to a focus on the acceleration slit, S_1, by small positive potentials placed on the two pusher electrodes, *P*. After passing through S_1, the ions are accelerated toward S_2 by a potential of 4000 to 400 v. The ions passing through S_2 enter the analyzing chamber where they are deflected through arcs whose radii are proportional to their momenta. All ions which do not pass through the collector slit (not shown) strike the walls of the analyzing chamber and become discharged. The electron acceleration slits, E_1 and E_2, are designed to give maximum electron emissivity and at the same time to prevent molecules cracked on the hot filament from diffusing into the ionization chamber. The filament itself is placed in the high vacuum region outside the ionization chamber to minimize chemical action between the hot tungsten and the gases being analyzed.

TABLE I.—CALIBRATION PATTERNS.

Relative Abundance of Ion Fragments from Pure Compounds.

m/e	Isoprene	n-Pentane	Iso-pentane	Neo-pentane	n-Hexane	Ethyl Alcohol	Benzene	Styrene	Vinyl Cyclo-hexene	Ethyl Ether
36	0.23	....	....	....	....	....	0.21	0.10	0.97	....
37	4.08	3.60	8.07	0.35	1.16	....	2.36	0.77	4.53	0.11
38	10.23	10.19	22.57	0.91	4.45	....	4.11	2.12	17.64	0.17
39	60.68	132.58	289.13	11.66	96.30	0.42	11.72	8.27	318.30	0.94
40	37.06	23.67	47.94	1.43	16.97	1.02	0.39	0.49	34.00	0.17
41	32.15	391.76	912.68	37.57	373.72	5.06	0.05	0.68	161.76	12.16
42	18.85	565.54	1166.38	2.25	212.87	17.66	....	0.29	7.90	5.59
43	0.68	984.27	1350.90	....	414.78	48.34	....	0.57	1.21	30.90
44	....	33.48	45.63	....	15.95	12.30	....	0.24	0.29	8.97
45	....	0.45	0.82	....	0.27	218.81	....	....	....	125.58
46	....	....	....	....	....	100.00	....	....	....	2.93
47	....	....	....	....	....	3.01	....	....	....	0.89
48	0.14	....	....	....	....	0.24	0.26	....	....	....
49	1.38	0.23	0.99	0.07	....	....	2.08	0.67	1.45	....
50	8.04	3.37	10.54	0.52	1.78	....	15.36	9.96	26.93	....
51	11.44	5.62	17.46	0.82	4.38	....	18.69	22.08	73.96	....
52	6.16	2.02	6.10	0.24	1.85	....	17.00	7.42	46.88	....
53	78.10	9.89	30.97	1.25	10.40	....	0.77	1.14	111.33	....
54	3.54	2.10	7.41	0.24	3.97	....	....	0.50	773.56	....
55	0.13	30.41	71.66	2.76	38.88	....	....	0.12	43.88	0.28
56	....	23.97	253.54	4.23	266.26	....	....	0.54	2.12	....
57	....	137.75	830.31	100.00	574.95	....	....	0.15	....	1.38
58	....	6.22	37.07	4.58	25.53	....	....	....	....	1.16
59	....	0.15	0.82	....	0.62	....	....	....	....	171.65
60	0.27	....	....	....	0.34	....	0.08	....	....	5.65
61	1.60	0.15	0.33	....	....	....	0.40	0.62	0.78	0.55
62	2.78	0.67	0.99	0.03	0.21	....	0.64	1.95	7.63	....
63	4.34	0.98	1.48	0.04	0.48	....	3.11	5.57	18.48	....
64	0.70	0.11	....	....	....	....	0.20	0.75	4.07	....
65	10.14	1.05	1.48	0.04	0.96	....	0.10	1.37	56.11	....
66	15.15	0.37	0.49	....	0.41	....	....	0.25	245.27	....
67	98.92	1.20	2.14	0.04	1.37	....	....	0.13	187.54	....
68	100.00	0.75	1.81	....	0.27	....	....	....	11.53	....
69	5.23	0.67	1.32	0.01	2.33	....	....	....	0.57	....
70	0.15	1.20	1.81	....	4.31	....	....	....	....	....
71	....	5.99	29.49	....	31.35	....	....	....	....	....
72	....	100.00	100.00	0.0	1.85	....	....	....	....	....
73	....	5.54	5.60	....	....	....	....	0.62	0.22	8.97
74	....	0.11	....	....	....	....	....	3.65	2.64	100.0
75	....	....	....	....	....	....	1.61	3.01	7.83	4.71
76	....	....	....	....	....	....	5.34	3.68	2.25	0.33
77	....	....	....	....	0.27	....	12.20	15.39	123.20	....
78	....	....	....	....	....	....	100.00	27.46	117.97	....
79	....	....	....	....	....	....	6.37	1.98	477.16	....
80	....	....	....	....	....	....	0.20	0.17	291.60	....
81	....	....	....	....	....	....	....	....	27.21	....
82	....	....	....	....	....	....	....	....	1.14	....
83	....	....	....	....	....	....	....	....	....	....
84	....	....	....	....	0.41	....	....	....	....	....
85	....	....	....	....	3.15	....	....	0.13	....	....
86	....	....	....	....	100.00	....	....	0.27	....	....
87	....	....	....	....	6.71	....	....	0.50	....	....
88	....	....	....	....	0.27	....	....	0.10	....	....
89	....	....	....	....	....	....	....	1.50	2.94	....
90	....	....	....	....	....	....	....	0.15	1.60	....
91	....	....	....	....	....	....	....	0.23	75.47	....
92	....	....	....	....	....	....	....	0.06	9.95	....
93	....	....	....	....	....	....	....	0.08	165.81	....
94	....	....	....	....	....	....	....	....	12.64	....
95	....	....	....	....	....	....	....	....	0.46	....
97	....	....	....	....	....	....	....	0.15	....	....
98	....	....	....	....	....	....	....	0.52	....	....
99	....	....	....	....	....	....	....	0.19	....	....
100	....	....	....	....	....	....	....	0.06	....	....
101	....	....	....	....	....	....	....	1.06	0.49	....
102	....	....	....	....	....	....	....	7.40	1.52	....
103	....	....	....	....	....	....	....	32.66	5.15	....
104	....	....	....	....	....	....	....	100.00	1.72	....
105	....	....	....	....	....	....	....	8.52	7.76	....
106	....	....	....	....	....	....	....	0.37	1.72	....
107	....	....	....	....	....	....	....	....	11.72	....
108	....	....	....	....	....	....	....	....	100.00	....
109	....	....	....	....	....	....	....	....	8.46	....
110	....	....	....	....	....	....	....	....	0.34	....
Sensitivity	14.39	3.26	1.51	33.00	4.00	6.5	44.73	44.66	19.66	5.41

The relative abundances of all masses are expressed in per cent of the base mass which has been given an arbitrary value of 100. Masses heavier than the base mass are due to heavy isotopes.

The positive ion beam, after passing through the accelerating slits, enters the analyzing chamber where it is deflected by a magnetic field into a series of arcs whose radii, r, are given $mv = Her$, where r is in centimeters and H in gausses. In order to prevent catterings of the resolved ion beams, the gas pressure is maintained between 10^{-6} and 10^{-7} mm. of mercury.

In a mass spectrograph the resolved ion beams are recorded simultaneously on a photographic plate. In a mass spectrometer the beams are recorded individually by being made to pass over a slit and an electrical measuring device. This is accomplished by adjusting either the accelerating potential or the magnetic field strength. This can be seen when the energy and momentum equations are combined and expressed as

$$\frac{m}{e} = \frac{H^2 r^2}{2E}$$

or simplified to

$$r = \frac{144\sqrt{mV}}{H}$$

where V is in volts. Thus, r for a given mass can be varied by changing either V or H. Both types of instruments are in use.

In the Consolidated mass spectrometer in use at the National Bureau of Standards, the magnetic field is held constant between broad mass limits while the potential on the accelerating slit is allowed to decay slowly through a high resistance. The positive ion current (10^{-14} to 10^{-10} amp.) for each resolved mass beam to the collector is amplified and fed into galvanometers whose deflections are recorded on moving photographic paper. A record con-

sists of a series of peaks spaced one or more mass units apart. The height of the peaks represents the relative abundance of each mass.

Molecular Fragmentation

When a hydrocarbon molecule is struck by a 50-v. electron, 9 to 14 v. are expended in ionization. The remaining energy in part or in total is dissipated in molecular excitation or dissociation. The sequence of fragment masses obtained for any pure compound constitutes the "cracking pattern." Since a large number of molecules is involved, peaks for all possible fragments are observed.

The cracking patterns for a number of hydrocarbons are given in Table I. The patterns for the C_4 hydrocarbons have been published (3).

No attempt will be made here to interpret the cracking patterns other than to say that they follow quite definite trends and that the order of magnitude of the various peaks can often be anticipated. For instance, the smallness of the C_5 peak for neopentane was predicted before the pattern was run.

In tabulating the comparative ratios for the various fragments, the height of the peak occurring at the mass of the parent molecule composed of normal carbon and hydrogen ^{12}C and H_1 is assigned an arbitrary value of 100. The only masses heavier than the base peak are small peaks due to heavy isotopes such as heavy carbon and deuterium, ^{13}C and D.

The sensitivity for each compound is given at the bottom of the table. Sensitivity is defined as the number of divisions of base peak per micron of gas pressure in the inlet system. As the peak heights are proportional to the pressure over the range in which the instrument is operated, the sensitivity of a given compound is independent of the sample pressure or of its partial pressure in a gas mixture.

Cracking patterns for some 150 different compounds have been obtained. As of January 1, 1946, 79 different hydrocarbons are available as National Bureau of Standards standard samples for calibrating spectrometers.[3]

Method of Analyses

The mass spectrum for a composite gas mixture consists of a series of mass peaks whose heights are the arithmetical sums of the cracking patterns of each constituent. In order to compute percentage composition from the mixture pattern, it is necessary to have the cracking patterns and sensitivities for each component. The calculation consists of subtracting separately the contribution of each component until the residuals become too small to be assigned to any compound. The sum of the pressures of the various components expressed in microns, μ, is taken as the total pressure; no constituent is determined by difference.

The method of calculation used at the National Bureau of Standards has been described in a previous publication (3). The computations for a simple mixture will serve to illustrate the various steps. In Table II are given the mixture patterns and the contributions of each component in a sample of commercial butadiene.

In making the calculations the contribution of the heaviest component, vinyl cyclohexene, is subtracted first from the mixture pattern. The pentenes are subtracted next; since only a trace of pentenes is present, the pattern for pentene 1 is used. Pentadienes are then subtracted followed in turn by *n*-butane. Isobutane is eliminated by the ratio of the 58 to the 43 peaks.

TABLE II.—BUTADIENE ANALYSIS.
Contribution of Various Components to the Mixture Pattern.

m/e*	Mixture Pattern	Vinyl Cyclohexene	Pentene-1	1,4-Pentadiene	*n*-Butane	Butene-1	Butene-2	1,2-Butadiene	1,3-Butadiene	Carbon Dioxide	Propylene	Propadiene	Residuals
36	6.7	...	...	...	...	...	...	0.1	6.2	...	...	0.1	0.3
37	50.9	...	...	0.1	...	...	0.1	0.8	48.9	...	0.1	0.5	0.4
38	77.5	0.1	...	0.2	...	...	0.1	1.2	74.6	...	0.1	0.7	0.5
39	1074.0	1.4	0.1	1.1	0.1	0.3	1.2	6.7	1061.2	...	0.4	1.5	0
40	39.7	0.1	...	0.5	...	0.1	0.2	0.2	36.4	...	0.2	*2.0*	0
41	7.4	0.5	0.2	0.6	0.4	0.9	3.4	...	0.8	...	0.6	...	0
42	1.4	...	0.3	0.3	0.2	...	0.1	...	.....	...	*0.5*	...	0
43	1.3	...	...	...	1.3	...	...	...	.....	...	...	...	0
44	0.6	...	...	...	...	...	...	...	.....	*0.6*	...	...	0
48	11.7	...	...	...	...	...	...	0.1	11.4	...	...	...	0.2
49	75.0	...	...	...	...	...	...	1.1	73.1	...	...	...	0.8
50	269.1	0.2	...	0.1	...	...	0.2	3.8	263.4	...	...	...	1.4
51	261.9	0.3	...	0.1	...	...	0.2	3.6	257.0	...	...	...	0.7
52	132.9	0.2	...	0.1	...	...	0.1	1.9	130.0	...	...	...	0.6
53	723.0	0.6	...	0.8	...	...	0.3	7.0	713.0	...	...	...	2.1
54	1302.0	2.9	...	...	...	...	0.2	*18.5*	*1280.4*	...	...	...	0
55	58.6	0.2	0.3	...	...	0.2	0.9	0.8	56.2	...	...	...	0
56	3.7	...	...	...	...	*0.5*	*2.3*	...	0.9	...	...	...	0
57	0.3	...	...	...	...	...	0.1	...	.....	...	...	...	0.2
58	0.2	...	...	...	*0.2*	...	...	...	.....	...	...	...	0
65	0.4	0.2	...	0.2	...	...	...	...	.....	...	...	...	0
66	0.9	0.8	...	0.1	...	...	...	...	.....	...	...	...	0
67	1.6	0.6	...	0.9	...	...	...	...	.....	...	...	...	0.1
68	1.2	...	...	*1.2*	...	...	...	...	.....	...	...	...	0
69	0.1	...	...	0.1	...	...	...	...	.....	...	...	...	0
70	0.2	...	*0.2*	...	...	...	...	...	.....	...	...	...	0
77	0.4	0.4	...	...	...	...	...	...	.....	...	...	...	0
78	0.3	0.3	...	...	...	...	...	...	.....	...	...	...	0
79	1.4	1.4[a]	...	...	...	...	...	...	.....	...	...	...	0
80	0.9	0.8	...	...	...	...	...	...	.....	...	...	...	0.1
81	0.1	0.1	...	...	...	...	...	...	.....	...	...	...	0
Sensitivity	....	38.83	20.45	25.15	7.86	22.29	25.82	42.45	30.84	30.86	22.47	42.33	Tota
μ[b]	....	0.04	0.01	0.05	0.02	0.02	0.09	0.44	41.52	0.02	0.02	0.05	42.28
Per cent[c]	....	0.09	0.02	0.12	0.05	0.05	0.21	1.04	98.20	0.05	0.05	0.12	100.00

* *m/e* gives the ratio of mass to charge; only those peaks are noted in which $e = 1$.
[a] Microns of pressure, μ, of each constituent obtained by dividing the divisions of base peak by the sensitivity.
[b] The percentage composition is computed by considering the total pressure to be the sum of the pressures of the various constituents.
[c] In computing the vinyl cyclohexene contribution, the sensitivity of the 79 peak is used.

[3] Information regarding these hydrocarbons may be obtained by writing to the National Bureau of Standards in Washington, D. C.

The subtraction of the butenes is more complicated since the 54 peak is so large that it will make some heavy isotope contribution to the 56 peak. Since the butene contribution to the 54 peak is negligible, the amount of 54 peak due to isotopes can be estimated without error. This leaves 2.78 divisions for total butenes on the 54 peak. After correcting for the isotope contribution of butadiene to the 41 peak, 4.30 divisions are left for the butenes. The cracking patterns for the butenes show the 41 peak to be 1.463 times the 56 peak for butene-2 and 1.956 for butene-1. The relative amounts of the two can now be computed from the following linear equations:

41 peak = 1.463 butene-2 + 1.956 butene-1 = 4.30 divisions
56 peak = 1.00 butene-2 + 1.00 butene-1 = 2.78 divisions

These can be solved by determinants as follows:

$$\text{Butene-2} = \frac{\begin{vmatrix} 4.30 & 1.956 \\ 2.78 & 1.00 \end{vmatrix}}{\begin{vmatrix} 1.463 & 1.956 \\ 1.00 & 1.00 \end{vmatrix}} = \frac{-1.140}{-0.493} = 2.31$$

Similarly, butene-1 = 0.47 divisions.

Total butadienes can now be computed from the remaining 54 peak, while the split between 1,3, and 1,2-butadienes is made from the 39 peak by the following equations:

39 peak = 0.358, 1,2-butadiene + 0.829, 1,3-butadiene = 1067.8
54 peak = 1.00, 1,2-butadiene + 1.00 1,3-butadiene = 1298.9

After subtracting the butadiene contributions, the remaining residuals indicate the presence of carbon dioxide, propadiene, and propylene.

The last column in Table II is for the residuals which cannot be accounted for by any known compound. Residuals are found in all calculations. They are due primarily to the fact that the cracking patterns change slightly from time to time, hence the patterns for the various components do not necessarily fit precisely at the time the mixture pattern was run.

Gas and Hydrocarbon Analyses

Representative analyses covering the types of samples that are regularly tested at the National Bureau of Standards have been published (3). Theoretically it should be possible to analyze any mixture that can be admitted to the instrument in the vapor phase and for which the cracking patterns and sensitivities of all the components are known. Unfortunately, there are practical limitations that must be considered. Since the reproducibility of patterns is not exact, compounds having similar patterns are not easily separated in complex mixtures. For instance, cis and trans butene-2 cannot be separated in a hydrocarbon mixture in which the total butene content is small. On the other hand, in a mixture of butenes it is possible to separate these isomers to at least ±2.0 per cent. Even normal and isobutane may be difficult to separate in hydrocarbon mixtures when they are present to 1 per cent or less. In general, however, the butane separation is a very simple one and can be made to a small fraction of 1 per cent.

Complex gas and hydrocarbon mixtures containing as many as fifteen components are regularly analyzed with a reproducibility of ±0.1 to ±0.01 per cent for each constituent. Mixtures containing thirty components have been analyzed, the reproducibility being less satisfactory than for simpler mixtures.

In so far as can be told, any compound can be analyzed provided it can be admitted to the ionization chamber as a gas or vapor. Such gases as oxygen, the halogens, the oxides of nitrogen, and the noble gases offer no difficulty. Water vapor analysis is uncertain due to adsorption in the glass inlet system. While wet samples can be run occasionally without deleterious effects, the life of the tungsten filament, which is from 6 to 8 months for dry samples, may be cut to a week by the continuous analysis of samples saturated with water vapor.

Analyses of High Polymres

A special molecular pyrolysis technique developed at the National Bureau of Standards appears promising as a possible method for the mass spectrometric analysis of rubbers, plastics, and complex molecules which have negligible vapor pressures. The materials to be studied are heated in small molecular stills so designed that the initial products of fragmentation are frozen out on a surface cooled by liquid air without undergoing decomposition. Samples from 0.01 to 0.001 g. of material are required. The results so far obtained indicate that each different molecular structure is converted into characteristic breakdown products.

Analysis of Inorganic Materials

A method by which it should be possible to analyze inorganic materials for various constituents is being investigated at the National Bureau of Standards. It is applicable only to those elements which can be converted into volatile compounds.

The technique used can be illustrated by a specific example. In the analysis of salts for fluorine, an inverted V sample tube is used. A weighed quantity of the ignited salt is placed in one arm of the V while concentrated sulfuric acid is placed in the other. The cell is evacuated while being heated gently to remove any moisture and is then sealed off under vacuum. After the sulfuric acid is mixed with the salt, the cell is heated in an oven at 130 C. for 30 min. in order to convert all the fluoride to SiF_4. The mass spectrometric analysis is made by sealing the 3-mm. side-arm into the inlet system with wax, breaking off the tip *in vacuo*, and measuring the height of the SiF_3 peak. Since SiF_4 is a symmetrical molecule, it easily loses one fluorine atom on ionization (see neopentane); hence, SiF_3 is the largest peak. SiF_2 and SiF peaks are also present. The procedure is quantitative since the sensitivity of the mass 85 peak for known quantities of fluorine has been measured and found to be linear over the thousand-fold range investigated. The sensitivity is 10^{-6} g. = 0.5 division. Since deflections are regularly read to 0.1 division, the detection of a microgram of fluorine is possible. The presence of foreign gases does not interfere with the analysis unless their pressure is such that the entire sample cannot be metered into the mass spectrometer; in this event, it is either necessary to remove these contaminants from the initial sample, or to analyze a known fraction of the sample.

Analysis of Salts and Alloys

In general, the metallic elements are not easily converted into the gaseous form; hence, they are not susceptible to analysis in the conventional gas-source mass spectrometer. In consequence, special instruments must be used for salts and alloys. Three types have been devised but, since the ion source problem is very involved, it is not surprising that much more development has to be done.

Thermionic Source Mass Spectrometers:

Several mass spectrometers have been described in the literature using thermions as positive ion sources. Such instruments are limited in their application to the alkali and alkaline earth salts and are not quantitative except for the determination of isotope abundance ratios. Ion sources consisting of fused salts coated on platinum or tungsten filaments have been used by Brewer and Kueck (4), Bondy, Johannsen, and Popper (5), and Cook (6). Since the work function is not constant across the surface of a fused salt, such emitters are never satisfactory for precise measurements. An excellent positive thermion source can be made by impregnating platinum disks with the sample and then scraping the surface free of all deposits. When these disks are spot-welded to a tungsten hair-pin filament, they will emit ions of uniform energy. Since the ion current obtainable is small, sensitive electrical recording systems are required. A mass spectrometer using this type of source is now in operation at the National Bureau of Standards (7). Comparative atomic weights for potassium can be determined with this instrument to six significant figures (8). The absolute value is close to that accepted by the International Committee on Atomic Weights.

Furnace Source Mass Spectrometers:

A mass spectrometer equipped with a small furnace for the vaporization of salts has been developed by Nier (13). The instrument has proved very satisfactory for the measurement of isotope abundance ratios of a number of the elements. It is possible that a modification of this type of source can be used for the chemical analysis of inorganic salts.

Double Focusing Mass Spectrographs:

Mass spectrographs in which the ion beams are focused by combined radial electric and homogeneous magnetic fields have been built by Aston (14), Dempster (9), Bainbridge and Jordan (10), and Mattauch (11). Since these instruments do not require uniform ion energies, arc and electric discharge sources can be employed.

Mattauch and Ewald (12) have used a Tesla arc source for determining the isotope abundance ratios of a number of metallic elements. The satisfactory nature of their results suggests that instruments of the type they describe may be adapted to analysis of salts and alloys.

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1946 Heating and Ventilating Guide

The 24th edition of the *Heating, Ventilating and Air Conditioning Guide*, published by the American Society of Heating and Ventilating Engineers, includes in its technical section 51 chapters grouped under the general section headings of Principles, Human Reaction to Atmospheric Environment, Heating and Cooling Loads, Combustion and Consumption of Fuels, Heating Systems and Equipment, Air Conditioning, Special Applications, and Installation and Testing Codes.

New chapters have been added on fluid flow, and on owning and operating costs. A comprehensive listing of more than 75 codes for testing, rating, selecting and installing heating, ventilating, and air-conditioning equipment has been added to the chapter on codes and standards.

Data on properties of moist air and of water obtained from the most recent cooperative research of ASHVE and Towne Scientific School, University of Pennsylvania are given in tables covering the range, −160 to +212 F. An enlarged removable Mollier diagram for moist air prepared by John A. Goff is included.

New material from sponsored research on air flow in outlets has been added to the chapter on air distribution. A new air friction chart based on studies made at the ASHVE Research Laboratory has been prepared for the chapter on air duct design. To the chapter on hot water heating systems and piping has been added a chart showing pipe flow in pounds of water based on friction loss.

The chapter on refrigeration includes an enlarged presentation of the various refrigeration cycles. Air contaminants are defined and treated in a separate chapter which contains tables showing maximum allowable concentrations of contaminants in space used for human occupancy.

This Guide includes an extensive Catalog Data Section with an index for finding any desired product and it also gives the membership roll of the Society. Copies can be obtained from the ASHVE, 51 Madison Avenue, New York, N. Y., at $6.00 per copy, in blue cloth cover; page size is 6 by 9 in.

Beachhead

By Robert Burns[1]

In Gerald (Ordnance) Reinsmith's survey of procurement philosophies in the March ASTM Bulletin[2] he discussed the relative merits of the various systems from a strictly scientific standpoint. He omitted one factor which has had a powerful influence on the A.S.T.M. specifications written by Committee D-20 to cover plastics. This can be illustrated by a visit I made recently to a friend who buys and sells fabrics. I remarked on the relative inaccuracy of the wooden yardstick he was using. "Why don't you use metal?" I asked. He gave several logical reasons for using wood, and summed them all up by the single statement "We like it."

In plastics procurement, we are trying to substitute the admittedly imperfect yardstick of our A.S.T.M. specifications for the chaos of the grab bag. Now, reaching one's hand in the grab bag is a traditional manner of having fun, but when broad public interest is at stake we are compelled to forsake the carnival atmosphere of innocent lottery and replace it with a document which will permit doing business on a more precise, albeit pleasurable, basis. Under the A.S.T.M. philosophy of strength through voluntary action it is obvious that our specifications must be likable, that people must derive pleasure as well as profit from doing business under them.

We have been asked to what extent our twenty specifications on commercial plastics are being used in the trade. They were written since 1942, but in this short period we have seen increasing evidence that with all their faults more and more people are saying "We like them." In addition to being used as procurement bases, they are recognized source material in the Plastics Materials Manufacturers Association data sheets, the Society of the Plastics Industry Classification system, The Plastics Catalog and other important trade documents. Consequently we can truthfully say we have gained a beachhead, a toehold.

Perhaps the best way to explain why people should like our specifications is to outline the philosophies we have followed in preparing them.

No Dictators, Please

The average vendor screams in holy horror when anyone mentions specifications. He visualizes an all-powerful consumer group, standing over him like a flock of vultures, ready to ram a beautiful but completely unworkable specification down his tender throat. Now, his throat isn't *that* tender, nor the specification *that* unworkable, but any tendency to throat-ramming is definitely out so far as Committee D-20 is concerned. We hold that a piece of paper with a lot of words on it becomes a specification only when two or more people agree to do business under it. It is not an *ex parte* or unilateral affair.

Caution! Vendors at Work

As a matter of fact practically all our specifications were prepared in preliminary form by producers. These documents do not spring out of the ground like ragweed. Someone with a pencil and paper, and a lot of know-how must sweat out a preliminary draft knowing full well that eventually it must be approved by his fellow-producers, consumers, government representatives, university men, etc. Experience has shown that the average consumer is so busy, or so tired, that he can't be bothered turning out the first draft. Careful investigation has proved that he is so busy shooting troubles due to lack of specification control that he just doesn't have the time to write specifications. So the vendor, that bad man with the horns, sharpens up his pencil and goes to work. After his co-producers have tuned it up, the draft goes to the consumers who shake themselves out of a deep sleep long enough to vote a resounding NO. After a few more revisions, the various viewpoints are reconciled and we have an A.S.T.M. specification, giving further testimony that reasonable men can accomplish anything; other men don't count. Parenthetically it can be stated that producers have on occasion voted negatively because the specification was not severe enough, and we can cite several cases where producers have voluntarily revised the requirements upward to give the consumers advantage of subsequent improvements in the materials.

Winkum, Blinkem, and Nod

When a technician starts to write a specification for plastics he is immediately faced with the necessity of choosing the basic principle which shall thenceforth guide his pen. The first is the WINKUM system consisting of a completely functional or end-use specification which is generally greeted with a sly wink if the fellow who wrote it is present but with a loud guffaw if he isn't. This type of specification usually classifies the various materials by a basic number associated with prefixes, suffixes, footnotes, asterisks, exponents, subnumbers, and numerous other devices to designate a given material by precise engineering terms. For such a specification to work, three requirements are essential: (1) the purchaser must be able to convert his apparatus performance into the physical, electrical, and chemical properties of materials entering therein, (2) the purchaser must be prepared to do the comprehensive testing to see that he gets what he ordered, and (3) it must be assumed that the expense of such testing will be justified by the fact that two or more materials are acceptable under any specific group of properties.

The need for requirement (1) is fairly obvious and is true for any form of specification. Since chemi-

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Bell Telephone Laboratories, Inc., New York, N. Y.; Chairman, A.S.T.M. Committee D-20 on Plastics

[2] Gerald Reinsmith, "Preparation and Use of Specifications," ASTM Bulletin, No. 139, March, 1946, p. 41.

cal types are unmentionable in the so-called end use specification, the purchaser cannot assume inherent properties because legally the vendor can supply *any* material having the specified physical and electrical constants. Therefore requirement (2) becomes necessary, for nothing can be left to chance and no dependence can be placed on honesty, because honesty is not one of the essential ingredients of this specification; it is pure cold-blooded engineering. Now, if we must test each and every batch for a long list of engineering properties, the only economical justification is that several materials will do an equally satisfactory job and can be purchased competitively; hence requirement (3).

It is generally conceded that the end-use specification can more nearly approach perfection than the others. However, it is so frightfully cumbersome that the principal result is development of the art of winking. The slogan of the end-use boys might appropriately be "When better winks are made, etc."

The BLINKEM group believes that the consumer should tell the producer exactly how the materials should be formulated, that is, 2 lb. of basic resin, 3 tablespoonsful of a particular plasticizer, 31 g. of a specific color, a pinch of accelerator, a dash of lubricant, etc., etc. This results many times in formulas that make the producer-chemists positively blink in amazement.

Again we have three requirements: (1) The purchaser must convert apparatus performance into chemical formulation, (2) the purchaser must be able and willing to test each and every batch, and (3) the purchaser must take full responsibility for behavior of material.

Requirement (1) is prodigious. It means that each consumer must know the chemistry of every material he buys, indeed know it better than the fellow who makes the compounds, otherwise there would be no point in Mr. Consumer doiug the formulating. A few big consumers might be able to do it, but for the little run-of-the-mill fellow it would be out of the question. Since only a few purchasers are equipped with elaborate analytical equipment and personnel, requirement (2) is equally insurmountable. Furthermore, for the thermosets the job is virtually impossible. Under this type of specification the vendor is no longer a partner with regard to satisfactory performance, hence requirement (3). In this system the consumer takes the entire rap because of his supposedly superior chemical knowledge. The day has passed when he can scream his troubles into a technical serviceman's ear.

The NOD group are the middle-of-the-road boys who go teetering down the center stripe, trying to veer not too sharply toward the WINKUMS or the BLINKEMS. Among this group of teeterers you will find most of the members of Committee D-20. Their philosophy embraces a happy mixture of respect between supplier and consumer and is based on these requirements: (1) a belief that honesty, not omniscience, is the priceless ingredient of all procurement practices, and if you don't have honesty all you've got is plenty of nuthin', (2) the ability reasonably to correlate properties with performance—let's not kid ourselves, this will never be more than intelligent guesswork, (3) a firm conviction that you don't have to test every material in the world for every property in the world, and (4) a sincere desire that our specifications be living, workable documents, appealing alike to big and little consumers.

Requirements (1) and (2) are based on our admission that we are somewhat lacking in our ability to relate properties or chemical formulas to performance; but even if we could, the WINKUM and BLINKEM systems are too costly in money and happiness, for the atmosphere of distrust pervades them. Until that final day when we in Committee D-20 know it all, we shall lean heavily on mutual respect between vendor and purchaser. Besides, it's a lot of fun. Instead of snarling at each other, we solicit and enjoy each other's company. We've got to work together; why not get some fun out of it?

Requirement (3) is based on the fact that if you order a given chemical type such as cellulose acetate from an honest supplier (we have no others in the plastics industry) certain properties are implicit and need not be tested as a routine matter. Consequently, it is necessary only to test for a few properties which are significant and which might vary from batch to batch. This cuts the testing cost down to a mere fraction of the WINKUM system, and doesn't require the chemical expertness of the BLINKEM method.

Requirement (4) is based on our decision to give the nod to the compromise system, deserting the physical, electrical, and chemical property perfectionists, and abandoning the chemical fellows who can predict the performance of a distributor head by the amount of hexa in the compound.

In common with all middle-of-the-roaders we are continually under fire. The WINKUMS look upon us as indolent and shiftless, sacrificing noble purposes to the smiles of the plastics industry; a bunch of compromisers with wishbones where our backbones ought to be. The BLINKEMS, from the eminence of their test tubes and retorts, gaze with horror on the ignorance which begets testing a compound after it's made instead of making it right in the first place. The consumers shout invectives at us because "It's obviously a producers' specification" and the producers holler because "It's clearly a consumers' specification."

We NODS of Committee D-20 do not sit in a tower of ivory (Ivory, did you say? Ivory is old hat; let's make the tower of plastic) looking down with disdain upon the ignorant fellows in the plastics industry. Heck, we *are* the ignorant fellows. And we wrote our specifications for ignorant guys like ourselves. Every day more and more people use 'em because they like 'em. Proving once again that it's fun to be simple; it pays to be ignorant!

Factors Affecting the Tensile Strength of Injection-Molded Ethyl Cellulose Test Specimens[1]

By W. E. Gloor,[2] W. C. Goggin,[3] and H. K. Haviland[4]

FOREWORD

We have approximately 20 procurement specifications covering plastics. It is recognized that these documents will not achieve maximum prestige and usefulness until the process of molding test specimens is brought under specification control. Pointing out to an attentive audience that the physical and electrical properties of plastics can be shifted from here to there by the molding technique must be a lot of fun because practically everyone does it. But the arguments and bickerings that arise between consumers and producers because of molding variations are definitely not pleasant. Gloor, Goggin, and Haviland have decided to abandon the pointing-out set and to go to work on the problem. They are helping to pioneer in a task which will require years of effort, barrels of money, and buckets of sweat. They have taken a single chemical type, ethyl cellulose, and a single property, tensile strength, and have started the long trail leading to the substitution of reasonably reproducible techniques for the black art of molding. Good molding is an art, so is good testing, but we are determined that art shall be our servant, not our master. R. B.

THE test work reported here was undertaken at the request of Subcommittee VI on Specifications of A.S.T.M. Committee D-20 on Plastics during the early part of 1945. In an effort to set up specifications for tensile strength of ethyl cellulose molding plastics it was found that considerable variation existed among values submitted by interested producers. A program was set up involving three producers, to reconcile these differences and to obtain data based upon the newest A.S.T.M. test specimens described in Tentative Method of Test for Tensile Properties of Plastics (D 638 – 44 T),[5] then just revised. Two of these producers were (1) to select materials from their line corresponding to the seven grades of plastics listed, (2) to mold samples for testing by each of the three participating laboratories, and (3) to forward sufficient molding powder to permit injection molding of similar samples by the other participants, who in turn would distribute samples to all three laboratories, their own included. Upon completing, each series of molding powders would have been molded and tested by each of the three laboratories, giving nine sets of data upon the same material. From these data, it was hoped to determine whether molding or testing irregularities were responsible for the differences, and to set up minimum specification values which would be completely agreeable to all concerned.

Preparation and Testing of Specimens:

Samples from one molding-powder producer are designated as material A; this producer submitted seven samples (representing the complete list of A.S.T.M. grades).[6] Sample from the other molding powder producer who participated are designated as material B; six samples of this material, comprising all but the softest A.S.T.M. grade, were tested. Details of the molding and testing are shown in Tables V and VI where the work done by the first producer is referred to as that of Laboratory I, by the second as Laboratory II, and by the third participant as Laboratory III.

Results:

Results of tension tests are given graphically in Fig. 1 for material A and in Fig. 2 for material B. In these figures the highest and lowest values determined by each laboratory on the sample are indicated by light bars, and the average (of five or more determinations) by a heavy bar. Inspection of the data reveals that agreement among laboratories is good on samples molded by the same molder, but that agreement on samples molded by different molders is not so good, indicating that molding processes greatly influence test results. Elongation values are particularly erratic, and hence have been excluded from consideration for specification use. There is also some disagreement among the values obtained for the same type of material submitted by the two molding-powder producers.

To check on this, flow temperature was determined on all the samples by laboratories I and III, and the results are shown in Table I. With the exception of the grade 6 sample of material A and the grade 1 sample of material B, average values are within the ±5.6 C. limits allowed by A.S.T.M.[6] with the qualification that the samples of material B generally are on the low side. Satisfactory checks between laboratories I and III are found for flow of material A; on material B, however, laboratory I gets significantly higher flow values than laboratory III. Hence the materials are probably true to grade and differences should be sought elsewhere.

Generally, material A contains oleaginous plasticizers while material B is softened with complex aromatic phosphates. This probably accounts for the different behaviors on molding described hereinafter. It will be noted from the figures that, for material A, molder I produced specimens of higher tensile strength than II or III, while for material B, molder II usually got

[1] The data reported here are a result of cooperative test work conducted in the laboratories of Celanese Corp. of America, Plastics Div., Dow Chemical Co., and Hercules Powder Co.

[2] Hercules Powder Co., Parlin, N. J.

[3] Dow Chemical Co., Midland, Mich.

[4] Celanese Corp. of America, Plastics Div., Newark, N. J.

[5] 1944 Book of A.S.T.M. Standards, Part III, p. 1682.

[6] Tentative Specifications for Ethyl Cellulose Molding Compounds (D 787–44 T), 1944 Book of A.S.T.M. Standards, Part III, p. 1590.

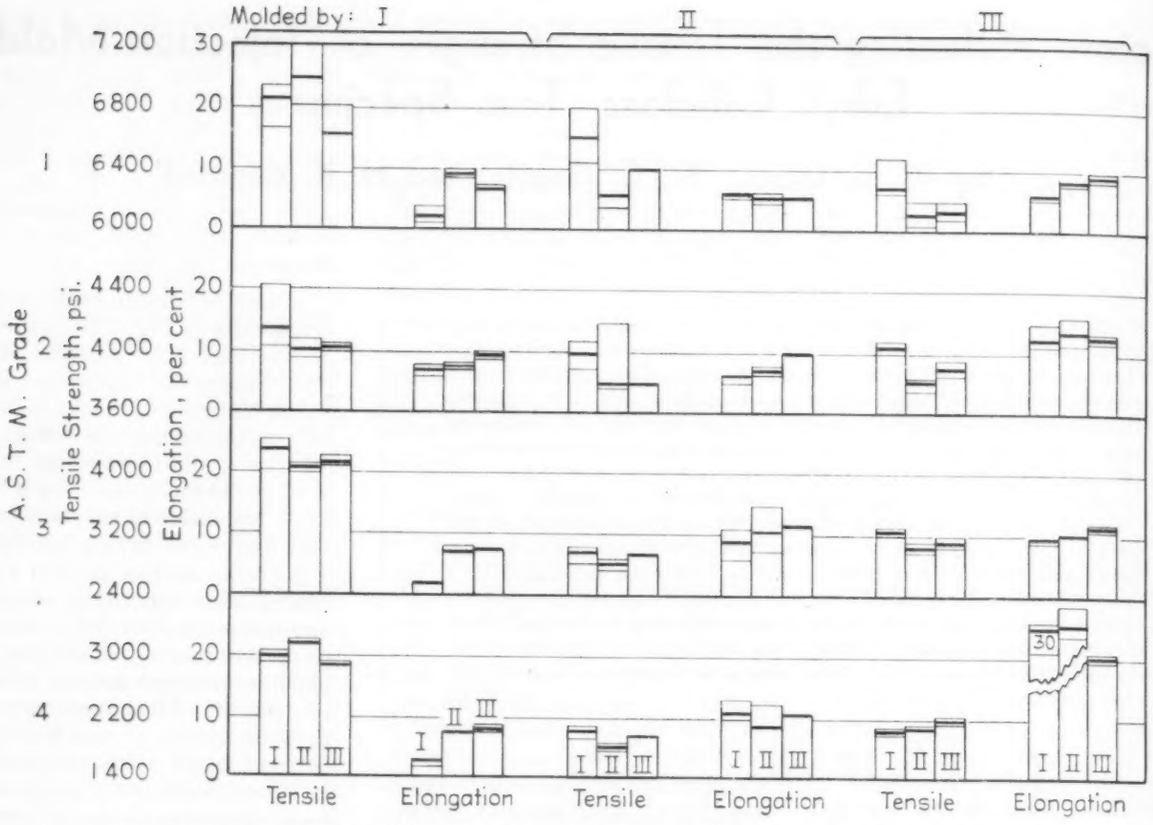

Fig. 1.—Comparison of Molding and Test Results on Standard Ethyl Cellulose Plastics—Material A.

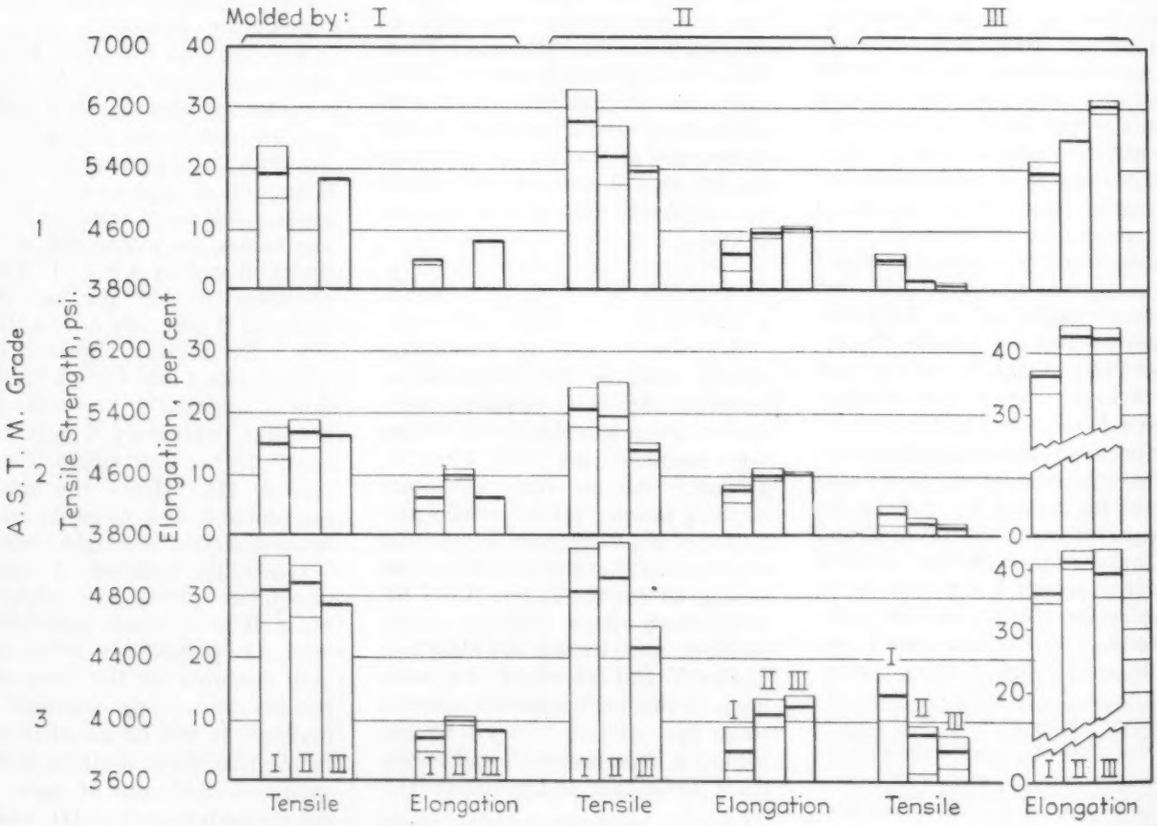

Fig. 2.—Comparison of Molding and Test Results on Standard Ethyl Cellulose Plastics—Material B.

TABLE I.—GRADING TESTS ON SAMPLES FOR A.S.T.M. TENSION COMPARISON PROGRAM TO DETERMINE CONFORMANCE OF MATERIALS TO GRADE LIMITS.

Grade	Flow Temperatures, deg. Cent.			
	Grade Value from A.S.T.M. Specification D 787[a]	Observed by:		In Grade
		Lab. I	Lab. III	
Material A				
1....	154	154	153	Yes
2....	143	143	141	Yes
3....	132	137	135	Yes
4....	121	126	121	Yes
5....	154	150	149	Yes
6....	143	137	134	No
7....	132	130	127	Yes
Material B				
1....	154	146	139	No
2....	143	143	138	Yes
3....	132	141	132	Yes
5....	154	153	143	Yes
6....	143	148	137	Yes
7....	132	139	132	Yes

[a] Possible deviations are ±5.6 C. from listed grade value.

the highest values. A more detailed breakdown of the tension data is shown in Tables II and III for materials A and B, respectively.

Variations Due to Testing:

In these tables, the data are collected for all samples of a given material molded by a given molder. Results are shown from each tester: the first line gives the high and low single values observed, and the second gives the arithmetic average value of the five individual tests recorded by each tester. The last three lines summarize, respectively, the highest individual reading obtained, the average of the three testers averaged (rounded off to the nearest 10 psi.) and the lowest single reading reported.

The range of the average values obtained between the testers is calculated for each molding compound as follows:

$$\text{Range of Averages} = \frac{\text{(Highest Tester's Average)} - \text{(Lowest Tester's Average)}}{\text{Average of Averages}} \times 1000$$

being expressed in psi. per 1000 psi. These values are summarized below:

Material	Molder	Range of Averages Found							Average Range of Averages for Each Tester
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	
A....	I	66	32	20	138	51	61	47	59
	II	52	40	58	109	83	89	105	77
	III	24	62	67	62	4	67	87	53
B....	I	21	50	59	...	63	41	31	44
	II	112	103	95	...	130	97	30	95
	III	73	51	89	...	65	127	81	81

The lowest range of averages appears to be obtained with samples molded by I and III—those with the smaller molding cylinders. On the average, different testers will get tensile strengths checking within 4 to 9 per cent upon samples molded by the same molder.

Variations Due to Molding:

To express simply what happens when tension specimens are molded from the same material by different molders, one must first decide upon the basis of comparison. For this, the highest "average of averages" obtained by all testers on the material under consideration was selected. For material A, all samples molded by laboratory I, which made this series, were high. For material B, made by molder II_1, results on five out of six of the grades were high.

The spread between test results obtained when specimens of the same materials are molded by different molders was calculated thus:

$$\text{Spread Due to Molding} = \frac{\text{(Highest Average of Averages)} - \text{(Lowest Average of Averages)}}{\text{Highest Average of Averages}} \times 1000$$

Spreads so calculated are shown in the following tabulation:

Material		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Average Spread
A.....	Spread.....	89	67	294	353	156	112	257	190
	Molder whose results were lowest.....	III	II	II	II	III	II	II	...
B.....	Spread.....	290	244	174	...	244	170	96	203
	Molder whose results were lowest.....	III	III	III	...	III	III	III	...

Similar results are obtained when the spread is calculated between the results of any one testing laboratory upon materials molded by the three different molders.

It is evident from this analysis that the variations in molding are more significant than those in testing, since on the same samples the range between the average results obtained by various testers on the same materials showed a mean value of 6 per cent, while the spread between the average test results of materials, molded by the different molders and tested by either a single tester or all testers, varied from 7 to 35 per cent and showed a mean value of 20 per cent.

Discussion

If the variations due to testing and molding should be additive, a variation up to about 45 per cent (10 per cent due to testing, 35 per cent due to molding) among different laboratories is perfectly possible. For example, consider material B, grade 1. Molded by laboratory II and tested by laboratory I, it gave an average of 5970 psi.; molded by laboratory III and tested by laboratory III, it gave an average of 3890 psi. The difference, 2080 psi., amounts to 42 per cent of the average of the results between the two laboratories.

It is of interest to attempt to account for the consistently low values obtained on samples molded by laboratories II and III on the samples of material A, and for the very low values obtained from samples molded by laboratory III on some plastics in the samples of material B. Table V presents the molding and testing conditions used by each of the participants, as far as they can be determined. Table VI indicates the chief points of variance.

The big difference among molders is in the heat exposure given the material. This may be roughly compared by the factor of plastic temperature (deg. Fahr.) multiplied by cycle time (seconds) multiplied by cylinder capacity (ounces) and divided by shot weight (ounces), called "heat factor" in Table VII. It will be seen that for material A, the lowest heat factor, indicating the least heat exposure, gave highest tensile strengths, while the highest heat factors gave lowest tensile strengths. For material B, the highest heat factor gave highest tensile strength except for grade 3 plastic. On examining the data

TABLE II.—TENSILE STRENGTH VALUES FOUND ON MATERIAL A.

Underlined Values Are Obtained by Averaging the Average Results of the Three Testers.

Molded by	Tested by	Tensile Strengths, psi.						
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
I.....	I High-Low	6950–6680	4440–4040	4290–4900	3060–2880	5460–5040	3440–3300	3390–3200
	I Average	6860	4150	4150	2960	5290	3380	3280
	II High-Low	7280–6800	4070–3940	4100–4000	3220–3180	5500–5420	3310–3120	3280–3060
	II Average	6970	4020	4080	3200	5450	3300	3160
	III High-Low	6670–6300	4080–4000	4340–4060	2890–2720	5230–5120	3260–3110	3230–2930
	III Average	6520	4040	4160	2790	5180	3180	3130
	Average of Highest	7280	4440	4340	3220	5500	3440	3390
	Average of Averages	6780	4070	4130	2980	5310	3290	3190
	Average of Lowest	6300	3940	4000	2720	5040	3110	2930
II....	I High-Low	6700–6250	4070–3890	3020–2820	2090–1970	4800–4560	3060–2960	2580–2380
	I Average	6500	3950	3000	2010	4690	3020	2460
	II High-Low	6280–5900	4200–3780	2850–2720	1850–1780	4500–4280	2870–2700	2330–2160
	II Average	6170	3800	2830	1800	4320	2760	2210
	III High-Low	6750–6110	3940–3730	2970–2910	2000–1945	4530–4410	3010–2920	2470–2430
	III Average	6400	3800	2940	1970	4470	2970	2450
	Average of Highest	6750	4200	3020	2090	4800	3060	2580
	Average of Averages	6360	3850	2920	1930	4490	2920	2370
	Average of Lowest	2900	3730	2720	1780	4280	2700	2160
III...	I High-Low	6490–6240	4080–4000	3280–3220	2240–2140	4600–4460	3240–3080	2560–2500
	I Average	6280	4040	3260	2180	4490	3150	2530
	II High-Low	6200–6030	3820–3750	3100–3030	2110–2030	4480–4430	3140–2910	2400–2310
	II Average	6130	3800	3050	2050	4470	2940	2320
	III High-Low	6220–6050	4010–3850	3170–3080	2240–2030	4550–4390	3260–2960	2500–2390
	III Average	6130	3900	3120	2100	4470	3070	2440
	Average of Highest	6490	4080	3280	2240	4600	3260	2560
	Average of Averages	6180	3910	3140	2110	4480	3050	2430
	Average of Lowest	6030	3750	3030	2030	4390	2910	2310

TABLE III.—TENSILE STRENGTH VALUES FOUND FOR MATERIAL B.

Underlined Values Are Obtained by Averaging the Average Results of the Three Testers.

Molded by	Tested by	Tensile Strengths, psi.					
		Grade 1[a]	Grade 2	Grade 3	Grade 5	Grade 6	Grade 7
I.....	I High-Low	5680–5000	5190–4800	5090–4630	4410–4070	3560–3370	3010–2880
	I Average	5310	4930	4850	4210	3480	2990
	II High-Low	.....	5300–4950	5000–4650	4270–3440	3600–3330	.....
	II Average	.....	5150	4880	3960	3440	.....
	III High-Low	5480–5020	5140–4280	4820–4400	4260–3770	3540–3220	3020–2760
	III Average	5200	4900	4600	4000	3340	2900
	Average of Highest	5680	5300	5090	4410	3600	3110
	Average of Averages	5260	4990	4780	4060	3420	2950
	Average of Lowest	5000	4280	4400	3440	3220	2760
II.....	I High-Low	6400–5590	5730–5190	5160–4450	4840–4380	3820–3440	3080–2930
	I Average	5970	5440	4840	4590	3590	3010
	II High-Low	5950–5360	5780–5170	5450–4400	4230–3940	3960–3380	3210–2990
	II Average	5540	5350	4920	4100	3780	3050
	III High-Low	5550–4910	5090–4730	4710–4260	4940–4550	3550–3330	3010–2860
	III Average	5340	4900	4470	4680	3430	2960
	Average of Highest	6400	5780	5450	4940	3960	3210
	Average of Averages	5620	5230	4740	4460	3600	3010
	Average of Lowest	4910	4730	4260	3940	3330	2860
III....	I High-Low	4230–4160	4190–3940	4310–4000	3560–3460	3800–2820	3010–2480
	I Average	4180	4080	4150	3500	3190	2780
	II High-Low	.....	4010–3870	3960–3660	3480–3400	2920–2680	2810–2250
	II Average	3900	3880	3910	3440	2810	2580
	III High-Low	3940–3830	4000–3800	3980–3630	3430–3160	3080–2660	3070–2490
	III Average	3890	3900	3800	3280	2980	2800
	Average of Highest	4230	4190	4310	3560	3800	3070
	Average of Averages	3990	3950	3950	3410	2990	2720
	Average of Lowest	3830	3800	3630	3160	2660	2250

[a] Samples softer than A.S.T.M. specification as judged by flow test.

from Table V, it will be seen that the highest tensile strengths for material B were obtained from samples molded at the lowest temperatures by laboratories I and II. Here it appears that the nature of the plasticizer and its response to temperature alone was different from that of material A. Hence it would appear that heat exposure or temperature of molding are the significant factors which account for the behavior of the same samples molded by different molders.

Conclusions

The dependence of tensile strength values upon molding conditions is a good illustration of the possibility of drawing incorrect conclusions as to material properties from specifications of the "bin"

TABLE IV.—SELECTION OF SPECIFICATION VALUES FROM TENSION TEST RESULTS.

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
Material A, Molded by Laboratory I							
Average	6780	4070	4130	2980	5310	3290[a]	3190
Lowest Test Average	6300	3940	4000	2720	5040	3110	2930
Material B, Molded by Laboratory II							
Average	5620[a]	5230	4740	..	4460	3600	3010
Lowest Test Average	4910	4730	4260	..	3940	3330	2860
Minimum Values Selected for Specification	5500	4000	3500	2500	4500	3000	2500

[a] Samples softer than A.S.T.M. Specification D 787 as judged by flow test.

TABLE V.—MOLDING CONDITIONS USED BY VARIOUS MOLDERS.

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
Laboratory I—Reed Prentice 10A2 machine, 2-oz. shot, no injection timer except on grades 2 and 6, where 1 sec. was used							
Material A:							
Front cylinder temperature, deg. Fahr.	575	512	497	470	570	500	480
Back cylinder temperature, deg. Fahr.	525	462	447	420	520	450	430
Plastic temperature, deg. Fahr.	450	410	400	380	450	400	390
Die temperature, deg. Fahr.	175	160	150	120	170	160	120
All at 10-10-10 cycle and 600 psi. gage pressure							
Material B:							
Front cylinder temperature, deg. Fahr.	510	490	485	...	535	520	500
Back cylinder temperature, deg. Fahr.	460	440	435	...	485	470	450
Plastic temperature, deg. Fahr.	410	400	390	...	430	420	400
Die temperature, deg. Fahr.	140	120	120	...	140	120	120
Pressure and cycle as for material A							
Laboratory II—Reed Prentice 10A8 machine, 2 to 4-oz. shot, no injection timer							
Material A:							
Cylinder temperature, deg. Fahr.	410–420	400–410	400–410	390–400	400–410	400–410	400–410
Plastic temperature, deg. Fahr.	395	385	385	375	385	385	385
Ram pressure, psi.	18 000	14 000	12 000	9000	14 000	14 000	12 000
All at 90-sec. cycle on 4-oz. shot, dies at 120 to 140 F.							
Material B:							
Cylinder temperature, deg. Fahr.	400 to 410 F. on all shots						
Plastic temperature, deg. Fahr.	385 F. on all shots						
Ram pressure, psi.	14 000	13 000	12 000	...	12 000	11 000	10 000
All at 60-sec. cycle on 2-oz. shot, dies at 120 to 140 F.							
Laboratory III—Reed Prentice 10A4 machine, 1-oz. shot, all on 10-10-3 cycle with 1/4 sec. injection timer (high volume) shot							
Material A:							
Nozzle temperature, deg. Fahr.	500	480	480	480	500	480	480
Cylinder temperature, deg. Fahr.	480	460	460	460	480	460	460
Plastics temperature, deg. Fahr.	450	420	420	420	450	420	420
Mold temperature, deg. Fahr.	180	180	180	180	165	180	180
Gage pressure, psi.	700	700	550	500	700	600	600
Material B:							
Nozzle temperature, 480 F.; cylinder temperature, 460 F.; plastic temperature, 420 F. in all cases							
Molding temperature, deg. Fahr.	150	150	150	...	170	170	150
Gage pressure, psi.	550	650	600	...	650	550	400

Notes on Testing:
All molds within revised A.S.T.M. Method D 638 dimensions-flow distances at 10 to 12 in., nozzle to end of tension bar.
Laboratory I—Used Amsler machine, pull at 0.25 in. per min. measure elongation after break. Conditioned in accordance with A.S.T.M. Method D 618,[a] 2 weeks; samples 8 to 10 days old or 6 weeks old found equivalent.
Laboratory II—Used Southwark machine at 0.05 in. per min. to 2 per cent, then at 0.25 in. per min., autographic strain recorder. Conditioned by D618,[a] 2 weeks; samples 8 to 10 days old.
Laboratory III—Used Southwark machine at 0.25 in. per min. autographic strain recorder. Conditioned by D 618[a], 2 weeks; samples 8 to 10 days old.
[a] Tentative Method for Conditioning Plastics and Electrical Insulating Materials for Testing (D 618–45 T), 1945 Supplement to Book of A.S.T.M. Standards, Part III, p. 257.

TABLE VI.—CONDITIONS WHICH VARY IN MOLDING PLASTICS.
All deemed nearly equivalent and conform to A.S.T.M. Method D 638.

	Material A	Material B	
Typical of grade	6 out of 7	5 out of 6	
Molded by	Lab. I	Lab. II	Lab. III
Cavities filled per shot	2	4 or 2	1
Molding Machine:			
Type—Reed Prentice	10A2	10D8	10A4
Cylinder capacity	(2 oz.)	(8 oz.)	(4 oz.)
Molding Conditions:			
Plastic temperature, deg. Fahr.	450–380	395–375	450–420
Cycle, sec.	30	60–90	23
Gage pressure, psi.	600	550–800	500–700
Rate of fill	Slow	Slow	Slow
Molding temperature, deg. Fahr.	120–180	120–140	150–180
Ratio, shot weight to cylinder capacity	1:1	1:2 or 1:4	1:4

TABLE VII.—"HEAT FACTOR" *VERSUS* TENSILE STRENGTH OF INJECTION MOLDED ETHYL CELLULOSE PLASTICS.
All numerals underlined = highest tensile or lowest heat factor. Last two numerals underlined = lowest tensile or highest heat factor.

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
MATERIAL A							
Molder I							
Heat factor (00 omitted)	135	123	120	114	135	120	117
Tensile strength, psi.	6780	4070	4130	2980	5310	3290	3190
Molder II							
Heat factor	711	695	695	675	695	695	695
Tensile strength, psi.	6360	3800	2920	1930	4490	2920	2370
Molder III							
Heat factor	414	386	386	386	414	386	386
Tensile strength, psi.	6180	3910	3140	2110	4480	3050	2430
MATERIAL B							
Molder I							
Heat factor	123	120	120	..	126	126	120
Tensile strength, psi.	5260	4990	4780	..	4060	3420	2950
Molder II							
Heat factor	944	944	944	..	944	944	944
Tensile strength, psi.	5620	5230	4740	..	4460	3600	3010
Molder III							
Heat factor	386	386	386	..	386	386	386
Tensile strength, psi.	3990	3950	3950	..	3370	2990	2720

type, unless molding conditions are explicitly stated.

To select tensile strength values, A.S.T.M. Specification D 787 – 44 T[6] provides that the molding conditions specified by the molding-powder manufacturer shall be used to prepare test specimens. Hence for material A, the values of laboratory I, and for material B, those of laboratory II, were used in arriving at the specification values shown in Table IV. This takes into account the fact, from Table I, that material B grade 1 sample is low in flow to be given that rating, and several other grades of material B are on the low side of the flow range.

The above work has been used in setting new specification limits for tensile strength to appear in a forthcoming revision of A.S.T.M. Specification D 787 – 44 T[6].

Acknowledgments:

Thanks are due for molding and testing work to the excellent cooperation of Messrs. W. P. Moeller, Celanese Corp. of America; J. L. Williams and E. C. Kropscott, Dow Chemical Co.; and W. O. Bracken and Max G. Wirick, Hercules Chemical Co.

Laboratory Testing of Plastics—Small-Scale Impact Test

By A. Bailey[1] and Owen W. Ward[1]

SYNOPSIS

A method and apparatus for testing impact strength quantitatively on small specimens has been developed. Specimen size is 1 by 0.1 by 0.2 in. The method employs an inclined glass tube and a steel sphere which is released from a vacuum throat, allowed to run down the inclined glass tube and collide with the notched specimen. The path of flight of the sphere after impact is in a horizontal direction and the length of the trajectory is a measure of the impact strength. Data are recorded on the experimentally determined impact strengths of various plastics. The reproducibility of the method is of the order of 1 per cent. The accuracy is probably similar to the standard Izod test. Illustrations and diagrams explain the construction.

NEED arose in this laboratory for an impact test to be used as a control in the research and development of an experimental lignin plastic. Since it was desirable to use laboratory-size apparatus in preparing the resins, it was apparent that important economy in time would result from the use of small test specimens rather than the relatively large A.S.T.M. specimens. It was considered advantageous to withdraw samples periodically from a reaction vessel, test each sample, and plot the complete time of reaction - strength relationship from this single experiment. Similarly, many variations in composition and procedure could be tested for optimum effectiveness with maximum economy of time and material. Actual use of the small-scale impact test since 1943 has fully justified confidence in its ability to accelerate research and in its merit as a legitimate control procedure which may find application in the laboratory development of plastics. The precise merits and demerits of such a small-scale test appear to be generally analogous to analytical chemistry on a micro *versus* macro scale. We do not suggest that a small-scale test is universal in application, or that it will replace any existing test. In special cases, such as our research in the face of wartime shortages, the method can render excellent service and may possess merit of interest to other laboratories unable or not desiring to use full-scale apparatus.

While the Izod and Charpy machines are recognized as standard, Church and Daynes (1)[2] employed a falling weight of progressively greater energy until the specimen broke. Marks (2) has made a recent application of the machine. Lubin and Winans (3) used the same principle to obtain both single-blow-impact and fatigue-impact values. Stock (4) used an inclined plane to impart energy to a sphere of graded size sufficient only to break the specimen. The use of graded blows was adopted by the various investigators to eliminate the error due to the energy imparted to the broken piece, as discussed by Telfair and Nason (5), Morey (6), Stock (4), and others to obtain a value which would provide a more reliable prediction of the behavior of a given plastic in actual service than was provided by the standard pendulum test. Better correlation between test results and actual service records is achieved by the graded blow tests.

These methods, in general, used a specimen of standard size which was considerably larger than that to which our experiments were adapted. Our problem, therefore, was to develop a method and machine which would test the impact strength of the specimens we had available. The desirable limitations on the impact machine were thus fixed by the size of specimen which had been developed and successfully used in testing flexural strengths (7). Beams broken in the flexure test yielded two specimens approximately 1.0 by 0.2 by 0.1 in., which were available for impact and subsequent tests. Our purpose therefore was not the development of theoretical knowledge, valuable as it might be, or the invention of a machine yielding more accurate predictions of service behavior, but rather, the development of a machine which would measure the impact of smaller specimens than heretofore tested, with approximately the same precision and accuracy as obtained in the standard Izod test, and to develop this machine for immediate use.

SURVEY OF POTENTIALLY USEFUL METHODS

Several variations of the pendulum-impact machine on a greatly reduced scale were constructed and tested. Hammer weights were of the order of 7 g., and height of fall about 8 in., both calculated from average impact strengths and the A.S.T.M. velocity. Pendulum suspensions were both rigid and flexible (copper wire, 0.0004-in. diameter), ranging in length from 8 to 36 in. Various releases were employed, including electromagnetic and collapsing-vacuum. Several recording devices, such as the path of a high voltage spark from the pendulum through a carbon paper, ratchet, stylus on carbon paper, and visual observation were utilized. Major errors and difficulties were introduced by the friction of mechanical recording devices, the nonreproducibility of releasing devices (even electromagnetic), and the skewness of the pendulum direction after impact. As the best reproducibility obtained in any of these methods was about 3 per cent, the pendulum method was abandoned as unpromising.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

The feasibility of utilizing other effects depending upon different principles was examined, together with the methods and devices of measuring and recording energy which seemed potentially useful. The most promising method appeared to be that using the energy of a projectile and the length of the trajectory as a measure of the energy remaining after impact with the specimen.

The method, as finally refined, employed an inclined tube to impart to a steel sphere a reproducible velocity in a horizontal direction. During horizontal flight, the sphere collided with, and broke, a notched specimen and continued its flight. The difference between free and impeded flight distances was regarded as a measure of the impact strength of the specimen. Our method was developed and put into use in 1943, and as we were not aware of Stock's work (4) with an inclined plane until 1945, we did not benefit from his contributions. Although our machine used a smaller specimen, Stock's machine was more accurate, since it eliminated error due to the flying piece. Stock's use of graded weights could probably be applied to our machine.

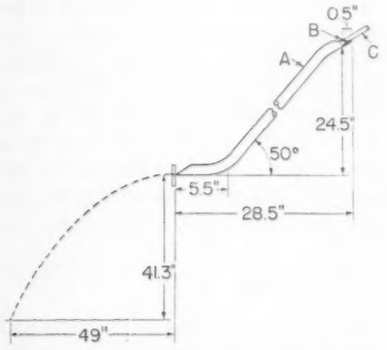

Fig. 1.—Diagram of Apparatus for Impact Testing.

Tube *A* was of Pyrex glass, 16 mm. O.D. Ball bearing *B* was 12 mm. in diameter, weighed 6.86 g. and was held by suction to tube *C*, 8 mm. O.D. with a square, fire-polished end. When the ball was released, it ran down the tube, broke the specimen upon emergence, and fell in a trajectory to the floor. The dotted line indicates the calculated trajectory of the ball with no specimen in the vise. Drawn to scale.

Apparatus for Impact Testing

Earlier study and development of a small-scale flexure test had made available a method for preparing a molded beam 2 in. long and having a rectangular cross-section approximately 0.2 by 0.1 in. (8). Pieces about one inch long which remained after flexure testing were logical specimens for the impact test. These specimens were notched with a file so that the thickness at the notch was 0.090 in. A special jig was made for this purpose by milling a rectangular groove in a rectangular bar of cold-rolled iron as shown in Fig. 3. The molded beam lay in the groove to a depth of 0.090 in. and was notched down to the metal. The jig was electroplated to withstand scratching.

The inclined plane consisted of a glass tube as shown in Fig. 1. At the upper end of the tube a polished steel ball bearing was held in position by suction on another tube. When held in the end of the tube by suction, the bottom of the steel sphere was in contact with the center of the inclined glass tube. The most reproducible release was obtained by closing the vacuum line and allowing leakage past the sphere to cause the release. An electromagnetic release was the least reproducible of all types tested, due to the variable rate of collapse of the magnetic field.

The specimen was mounted as shown in Fig. 2 at the bottom of the tube and held in the jaws of a vise in a special beam alignment jig (Figs. 2 and 3) which held the specimen and tube in such a position that

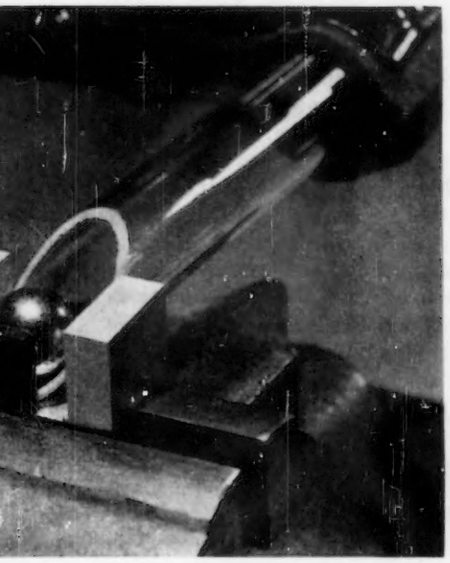

Fig. 2.—Photograph of Vise, Specimen, Beam Alignment Jig, Sphere, and Emergence End of Inclined Tube.

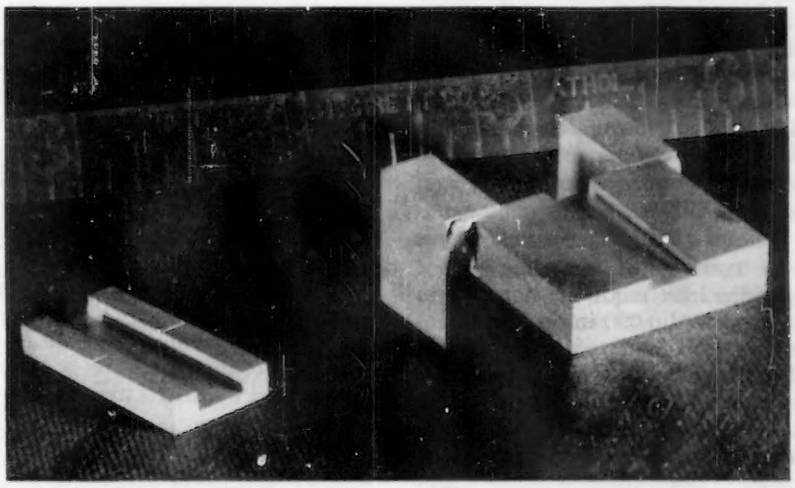

Fig. 3.—Notching Jig on Left, and Beam Alignment Jig.

the sphere struck the specimen in the center and 9/32 in. above the notch. This distance was called the cantilever distance. The relationship of vise, jig, tube, and sphere are shown in Fig. 2.

The point of impact of the sphere on the specimen was arbitrarily about 41 in. above the floor established initially and mainly by the table height. Under the conditions specified in Fig. 1, the length of free flight was about 49 in. On the floor underneath the path of flight was placed a length of carbon paper, carbon side up, covered with a white record sheet. The impact of the sphere on the floor recorded a sharp black carbon impression on the lower side of the record sheet, as shown in Fig. 5.

Testing Procedure

It was usual to test the mounting of the impact apparatus each time it was used for rigidity, alignment, adjustment, etc., with a plumb bob when necessary. It was imperative that the interior of the tube and the sphere be maintained in a clean condition. After this verification, the aspirator was turned on, the sphere carefully wiped off fingermarks and put in place, touching the inclined tube on its longitudinal axis, with due precautions not to leave the surface dirty. The vacuum on the sphere was then collapsed by closing a spring clamp on the vacuum hose and allowing leakage past the sphere. After perhaps a second later, the sphere began its fall, traversed the tube, went through the unobstructed alignment jig, fell to the floor, and left a carbon impression on the record sheet. To prevent scratching the sphere, it was caught in a cardboard box on the first bounce. Several such free falls were made before actual tests, to assure alignment, cleanliness, and reproducibility.

The molded beams or half beams were conditioned according to the specifications required, notched to the depth of 0.090 in. in the notching jig, and mounted in the vise in the beam alignment jig. The notch was placed on the side of the impact and at exactly the level of lower exterior surface of the tube. The sphere was then cleaned and mounted in the vacuum throat in the usual manner. When the vacuum collapsed, the sphere traversed the tube, collided with and broke the specimen and continued its flight to the record sheet on the floor. The impact mark on the record sheet was inscribed with the code number of the specimen and the point vertically below the point of impact was marked. After the tests were completed, several more free falls were recorded and the sheet retained as a permanent record.

Calculation of Test Results

Two methods were used to derive the velocity of the sphere at the time of impact: by calculating it as a freely falling body from the point of rest to the point of impact, and by calculating backward from the trajectile distance and the height of drop from the point of impact to the floor. The former indicated a velocity of 137.6 in. per second and the latter 106.5 in. per second. Experiments with spheres of different size indicated that the anomaly was caused by the column of air in the tube producing viscosity, friction, and compressibility effects similar to recoil in ballistics. It is remarkable that they caused a difference of 29 per cent. The latter value, 106.5 in., was therefore considered the most reliable, and was used in subsequent calculations. No attempt was made to introduce a correction for wind resistance in flight, since, as noted below, theoretical correlation of the test was impossible under present limits of knowledge. The total kinetic energy of the sphere at the point of impact was calculated from the trajectile distance and the height of drop. The kinetic energy remaining in the sphere after impact was calculated from the impeded trajectile distance and the height of drop and subtracted from the calculated total kinetic energy of the sphere the instant before impact. This difference was called the impact strength of the material.

The actual values and equations used are shown briefly. The time required for the sphere to fall from the point of impact to the floor was determined by the relationship:

$$h = \tfrac{1}{2} gt^2 \quad \ldots\ldots\ldots\ldots (1)$$

where h, g, and t equal height, acceleration, and time, respectively. The value for h was measured and found to be 41.3 in. The time for the sphere to drop from the point of impact to the floor was therefore 0.462 sec.

The velocity at the instant of impact was determined by the relationship:

$$d = vt \quad \ldots\ldots\ldots\ldots (2)$$

where d, v, and t equal distance, velocity, and time, respectively. The horizontal length of trajectory of a free fall was 49.0 in. and the velocity at the instant of impact was therefore 106.6 in. per second.

The total kinetic energy of the sphere at the instant of impact was calculated from the equation:

$$\text{K. E.}_{(\text{total})} = \frac{1}{2}\frac{mv^2}{g} \quad \ldots\ldots\ldots (3)$$

where m and v equal mass and velocity, respectively. Since the sphere weighed 0.242 oz., its kinetic energy was 3.55 in.-oz. The kinetic energy absorbed in breaking the beam is the total kinetic energy at the instant before impact minus the kinetic energy remaining in the sphere the instant after impact, or:

$$\text{K. E.}_{(\text{absorbed})} = 3.55 - \frac{1}{2}\frac{m_1 v_1^2}{g} \quad \ldots\ldots (4)$$

where m_1 and v_1 equal the mass and the impeded velocity, respectively. The value v_1 was determined from the time of fall to the floor, 0.462 sec., and the experimental impeded trajectile distance (horizontal distance traveled by sphere after impact). Substituting the appropriate values determined experimentally in Eq. 4 resulted in the simplification:

$$\text{K. E.}_{(\text{absorbed})} = 3.55 - 0.00146d^2 \quad \ldots\ldots (5)$$

where d equals the impeded trajectile

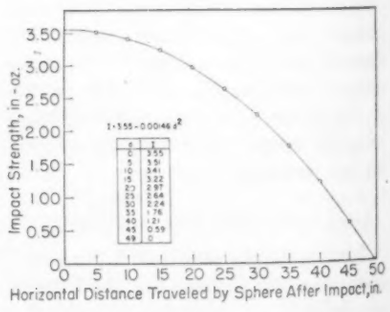

Fig. 4.—Relationship Between Impact Strength and Distance of Flight of Sphere After Breaking Specimen.

distance. Substituting values between 0 and 49 in. (the horizontal distance of a free fall) in Eq. 5 resulted in the data plotted in Fig. 4, which permitted reading $K.E._{(absorbed)}$ directly from the curve for any experimental value of impeded trajectile distance. The kinetic energy absorbed in the impact was called the impact strength of the material.

Results of Tests on Plastics

Molding powders of commercial plastics as well as molding powders of experimental plastics were molded into test beams, tested for flexural strength, and the broken pieces from the flexure test used as impact specimens. The results of some of these tests, all by the reduced-scale method, are given in Table I.

TABLE I.—IMPACT STRENGTH OF BUTASIN AND COMMERCIAL PLASTICS BY REDUCED-SCALE TEST.

Designation and Composition of Plastic	Impact Strength, in-oz.	Conditioning of Beam for Test
Butasin, lignin resin alone[a]	1.16	Green[b]
	0.86	Green[b]
	1.00	Green[b]
Butasin with 10 per cent tricresyl phosphate	0.80	48 hr. at 50 C.
Butasin with 10 per cent *o*- and *p*-toluene sulfonamide	1.18	48 hr. at 50 C.
Butasin with 10 per cent triethyl citrate	0.72	48 hr. at 50 C.
Butasin with 10 per cent butyl phthalyl butyl glycollate	0.83	Green
Butasin with 50 per cent wood flour	0.68	Green
Butasin with 50 per cent cotton fibers, ¼-in. staple	3.07	Green
Butasin with 25 per cent cotton fibers, ¼-in. staple	3.55+	Green
Butasin with 15 per cent glass fibers, ¼-in. staple	1.05	Green
Butasin with 10 per cent tricresyl phosphate and 5 per cent fibers, ¼-in. staple[c]	1.91	24 hr. at 105 C.
Butasin with 10 per cent tricresyl phosphate and 5 per cent fibers, ¼-in. staple[c]	1.77	48 hr. in water[d]
Commercial plastic A, high impact phenolic	1.78	24 hr. at 105 C.
	1.97	24 hr. at 105 C.
	2.06	48 hr. at 50 C.
	1.61	48 hr. in water[d]
	1.25	48 hr. in water[d]
Commercial plastic B, acrylic	1.60	24 hr. at 105 C.
	1.51	48 hr. in water[d]
	1.61	48 hr. in water[d]
Commercial plastic C, maple ligno-cellulose (hydrolyzed wood)	2.08	24 hr. at 105 C.
Commercial plastic D, same as C but phenolic resin added	1.13	24 hr. at 105 C.
	1.03	24 hr. at 105 C.
	1.38	48 hr. at 50 C.
	1.01	48 hr. in water[d]
Commercial plastic E, redwood ligno-cellulose and furfuryl alcohol resin	1.48	24 hr. at 105 C.

[a] Reference 9.
[b] Tested immediately after molding, no conditioning treatment.
[c] Actual ratio was butasin : tricresyl phosphate : cotton staple = 100:10:5.5.
[d] At room temperature.

Reproducibility of Impact Test

The reproducibility of a free fall of the sphere was about 1 per cent. A photograph of the record of several such free falls is shown in Fig. 5.

The reproducibility of an actual test of impact strength was probably slightly larger since additional errors were introduced. Most experimental materials which could serve as specimens had an actual variation from one specimen to another of at least 10 per cent above and below the average of the material, although the tests on the acrylic plastic varied only 4 per cent from the average (Table I). This is approximately the variation found by Stock in tests of a mineral-filled Melmac resin. A list of the sources of error in the impact test would include the variation in distance of free fall arising from imperfect centering of the sphere before release, variable condition of the interior of the tube or surface of the sphere, actual nonreproducibility of the collapsing vacuum, the variation in thickness of the beam at the notch, error in lining up the notch exactly with the top of the jaw of the vise, and possibly small variations in the angle of impact due to alignment of the specimen. In general, most of the errors appeared to be compensating due to random occurrence, rather than additive in character.

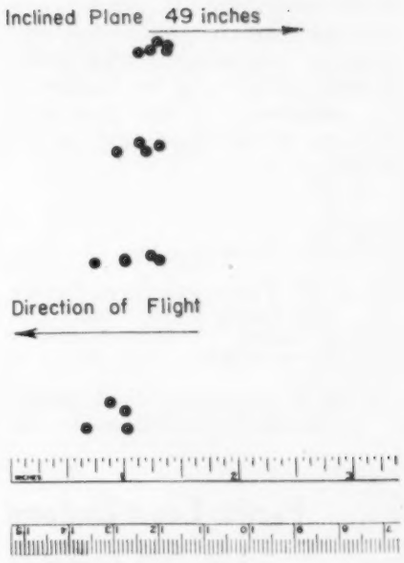

Fig. 5.—Unretouched Photograph of Experimental Record of Free Falls.

The dots are the marks from the carbon paper made by the impact of the sphere on the white record sheet.

Discussion

Little can be said of the fundamental correctness of any impact test. All are empirical measures under carefully specified conditions which attempt to predict the behavior of the specimen under actual conditions of use. The success of such predictions varies considerably with the method employed. Private correspondence with Research Subcommittee of A.S.T.M. Committee D-20 on Plastics revealed that the mechanics of the Izod test have not been amenable to mathematical analysis. While attempts to analyze the test have been made (9) and used with apparent success on certain materials (10), correlation between different methods at the present time is impossible of accomplishment. The same condition applies to correlation between standard-size specimens and reduced-scale specimens.

It was not our intent to rid the impact test of all the ills to which it is heir, but rather to develop a reduced-scale impact test to permit comparative testing of plastics in impact strength for research control work. The reduced-scale test yielded consistent results on each of several given materials and appeared to rank them in a reasonable series, although the correlation with other tests is unknown. The reduced-scale method offers advantages to the average laboratory in accelerating research on plastics through the use of apparatus of a size found in most laboratories and by permitting many tests at different points in an experiment. It was thus usually possible to obtain all necessary experimental data from a single experiment, and to follow precisely and easily the changes wrought by the deliberate shift of an experimental variable.

It seems possible that the reduced-scale test might be useful in studies

of the impact strength differences in core- and skin-material of thin sections in comparison with massive sections, in following the kinetics of the penetration of the heat-front into the plastic mass, and similar investigations.

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(8) A. Bailey and O. W. Ward, "Synthetic Lignin Resin and Plastic," *Industrial and Engineering Chemistry*, Vol. 37, p. 1199 (1945).

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(10) L. H. Callendar, "New Methods for Mechanical Testing of Plastics," *British Plastics*, Vol. 13, Nos. 155 and 156, April and May, 1942.

Pacific Coast Uniform Building Code Revised

THE 1946 edition of the Uniform Building Code promulgated by the Pacific Coast Building Officials Conference has been issued. Published as of Jan. 1, 1946, the new Code includes extensive revisions and additions approved at the September, 1945, Annual Meeting of the Conference. The revised Code continues to make extensive references to the standard specifications and tests issued by A.S.T.M. and references to the standards developed by a number of other organizations.

The January issue of the Conference Monthly Magazine *Building Standards* analyzes the revisions to the Code indicating that sections changed include those covering administration, heavy timber construction, masonry, stairs and exits, chimneys, vents, and fireplaces, motion picture projection rooms, and heating appliances. A completely new chapter on pre-fabricated construction has been incorporated, as well as new sections regulating glued construction—entirely new material that has never before been included in a building code.

A list of the A.S.T.M. specifications and tests which are embodied in the Code and are considered to be a part of it when not in conflict with a specific statement to the contrary, follow:

A 7 – 42	Structural Steel for Bridges and Buildings
A 15 – 39	Billet-Steel Bars for Concrete Reinforcement
A 16 – 35	Rail-Steel Bars for Concrete Reinforcement
A 27 – 44	Carbon Steel Castings
A 48 – 41	Gray Iron Castings
A 53 – 44	Welded and Seamless Steel Pipe
A 82 – 34	Cold-Drawn Steel Wire for Concrete Reinforcement
A 160 – 39	Axle-Steel Bars for Concrete Reinforcement
A 245 – 44 T	Light Gauge Structural Quality Flat Hot-Rolled Carbon Steel
C 5 – 26	Quicklime for Structural Purposes
C 6 – 44	Normal Finishing Hydrated Lime
C 10 – 37	Natural Cement
C 19 – 41	Fire Tests of Building Construction and Materials
C 22 – 41	Gypsum
C 28 – 40	Gypsum Plasters
C 31 – 44	Making and Curing Concrete Compression and Flexure Test Specimens in the Field
C 33 – 44	Concrete Aggregates
C 34 – 41	Structural Clay Load-Bearing Wall Tile
C 35 – 39	Sand for Use in Plaster
C 37 – 42	Gypsum Lath
C 39 – 44	Test for Compressive Strength of Molded Concrete Cylinders
C 52 – 41	Gypsum Partition Tile or Block
C 55 – 37	Concrete Building Brick
C 56 – 41	Structural Clay Non-Load-Bearing Tile
C 57 – 39	Structural Clay Floor Tile
C 61 – 40	Keene's Cement
C 62 – 44	Building Brick (Made from Clay or Shale)
C 67 – 44	Methods of Sampling and Testing Brick
C 73 – 39	Sand-Lime Building Brick
C 90 – 44	Hollow Load - Bearing Concrete Masonry Units
C 94 – 44	Ready Mixed Concrete
C 126 – 44 T	Glazed Masonry Units
C 129 – 39	Hollow Non-Load-Bearing Concrete Masonry Units
C 130 – 42	Lightweight Aggregates for Concrete
C 141 – 42	Hydraulic Hydrated Lime for Structural Purposes
C 144 – 44	Aggregate for Masonry Mortar
C 145 – 40	Solid Load-Bearing Concrete Masonry Units
C 150 – 44	Portland Cement
C 152 – 41	Methods of Fire Tests of Door Assemblies
D 146 – 44 T	Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing
D 805 – 44 T	Testing Veneer, Plywood, and Other Wood and Wood-Base Materials

Copies of the latest edition of this Code can be procured from the Pacific Coast Building Officials Conference, 124 West Fourth St., Los Angeles, Cal., $2.50 per copy.

Steel Construction Standards

THE new "Code of Standard Practice for Steel Buildings and Bridges," as revised November 1, 1945, by the American Institute of Steel Construction, has been extended to apply to structural steel for bridges as well as buildings, and it now covers welded as well as riveted and bolted fabrication. The Institute has also just issued a revision, as of February, 1946, of its widely used "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings." This document covers administration and technical provisions; among the latter are materials, loads and stresses, unit stresses, design and fabrication.

A number of leading authorities concerned with steel construction have participated in bringing this construction specification up to date. Copies of the two booklets, the Code of Standard Practice and the Specifications, can be obtained from the AISC, 101 Park Avenue, New York 17, N. Y.

Direct Volume-Reading Jolly Balance[1]

By Alfred S. Berens[2]

ALMOST all Government and industrial specifications for synthetic rubber call for the determinations of the volume change resulting from immersion in liquids, so that a large number of immersion tests are required by rubber laboratories in the development and evaluation of new compounds and rubber chemicals and in the control of production recipes. The standard method used in making these "swell tests" has been the water displacement method (Section 8 (a) of A.S.T.M. Tentative Methods of Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids, (D 471 – 44 T))[3] in which the volume change is determined by weighing the sample in air and in water both before and after the specified immersion, the weighings usually being made to the nearest milligram on an analytical or conventional Jolly balance.

In order to simplify and accelerate the mechanical operations of these volume determinations, as well as to simplify the work sheets and calculations involved, a modified Jolly balance has been developed so as to give direct volume readings, the use of which involves no essential deviation from the above-mentioned specification.[3]

The balance (Figs. 1 and 2) consists essentially of a standard Jolly balance spring (for example, E. H. Sargent and Co., No. S-3095), having a sensitivity of 5-cm. elongation per gram, from which is suspended a sighting disk and the rubber sample. Behind and parallel to the vertical axis of the spring is an adjustable, graduated, transparent tape, the divisions on which go from zero at the lower end to about six at the upper end. A mirror is mounted immediately behind the tape so that readings made across the sighting disk to the transparent scale may be free from errors due to parallax. Also included in the apparatus is a movable platform on which a 250-ml. electrolytic form beaker may be raised and lowered. Both the tape and the beaker support are operated from outside an enclosing glass case in a manner similar to that in which chain-type balances are operated.

The transparent tape (Fig. 3) was constructed by drawing the desired divisions on white paper, photographing the entire scale, and then making a positive print on film. The distance between primary scale divisions on the final print is about 5 cm. and the total length of the graduated portion of the tape is about 30 cm. The transparent scale was made part of an endless belt by cementing it to a fabric tape which passed over the drive and support pulleys and which was held under constant tension by short springs.

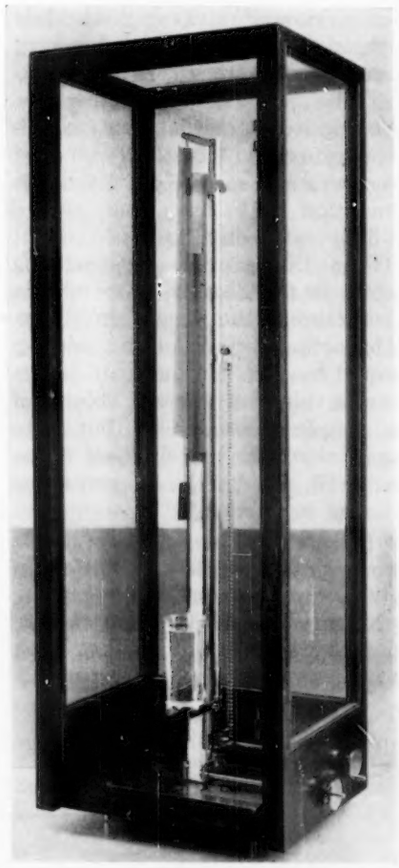

Fig. 1.—Photograph of Modified Jolly Balance.

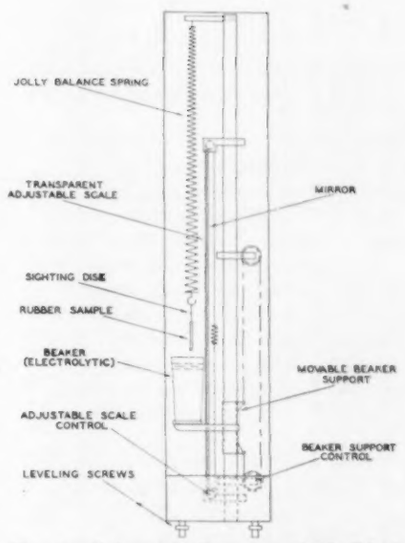

Fig. 2.—Schematic Drawing of Modified Jolly Balance Shown in Fig. 1.

The determination of the volume of a sample consists simply of suspending the sample from the spring, adjusting the tape to zero when read across the sighting disk, elevating the beaker so as to immerse the sample in water, and reading the volume from the tape, again sighting across the disk.

Since the elongation of the spring is directly proportional to the weight of the sample, the change in elongation, ΔL, is directly proportional to the apparent loss in weight resulting from the immersion of the sample in water. That is,

$$W_1 - W_2 \sim \Delta L$$

where:

W_1 = weight in air, and
W_2 = weight in water.

Also, since $V = \dfrac{W_1 - W_2}{d}$, where V = volume of sample, and d = density of water = 1.0, the

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[1] Paper presented at meeting of Subcommittee XIX on Tests for Properties of Rubber and Rubber-Like Materials in Liquids, of A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials, February 27, 1946, at Pittsburgh, Pa.

[2] Research Laboratory, Chicago Rawhide Manufacturing Co., Chicago, Ill.

[3] 1944 Book of A.S.T.M. Standards, Part III, p. 1787.

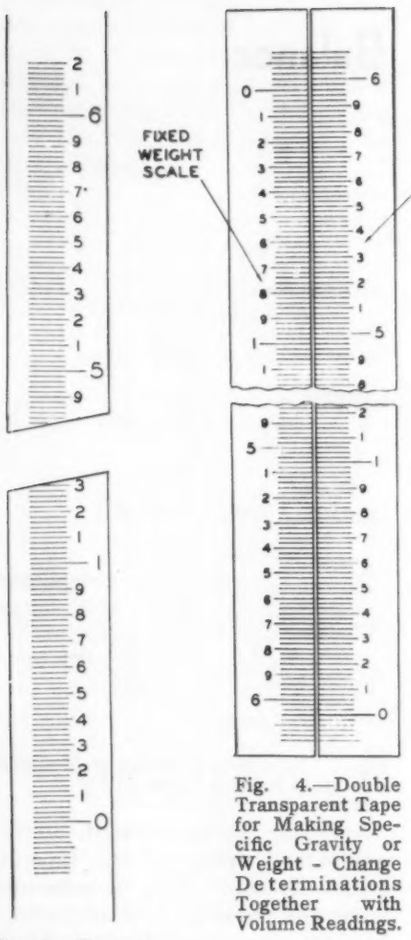

Fig. 3.—Transparent Tape Used in Reading the Volume.

Fig. 4.—Double Transparent Tape for Making Specific Gravity or Weight - Change Determinations Together with Volume Readings.

change in the elongation of the spring is directly proportional to the volume of the sample, or

$$V \sim \Delta L$$

In A.S.T.M. Tentative Method D 471,[3] the percentage increase in volume may be easily calculated by

$$\text{Per cent } \Delta V = \frac{V_2 - V_1}{V_1} \times 100$$

where

Per cent ΔV = percentage increase in volume of sample,
V_1 = initial volume of sample, and
V_2 = volume of sample after immersion test.

A somewhat easier slide rule method of computing the percentage increase in volume is given by

$$\text{Per cent } \Delta V = \frac{100V_2}{V_1} - 100$$

which requires merely the setting of the two volume readings obtained from the Jolly balance.

Actually, since the tape is uncalibrated, the apparent volume as read from the transparent tape is not the true volume but instead may be represented as

$$V_{\text{apparent}} = kV_{\text{true}}$$

where k is the factor of proportionality correlating the elongation of the spring with the scale divisions on the tape. Nearly all swell tests report volume change as a percentage of the original, so that it is not usually necessary to know the value of k. It may, however, be easily determined by comparing the volume obtained on an analytical balance with that obtained on the Jolly balance. Using a spring with a sensitivity of approximately 5 cm. per gram and having about 5 cm. between primary scale divisions on the tape, one primary unit is approximately equal to 1 cu. cm., and k is very nearly equal to unity.

The problem of wetting the sample is not one inherent in this apparatus but must be provided for as in any specific gravity determination. It has been found wholly satisfactory to add about 0.5 to 1.0 per cent of a wetting agent to the distilled water used in determining the weight in water. The actual density of the solution would have to be known if an accurate value for the true volume of a sample were desired, but here again this error cancels itself if the required result is a percentage change in volume.

Results may be recorded on simple work sheets which in addition to giving the pertinent data regarding stock number, liquid, aniline point, test temperature and duration, need contain only three columns—one for original volume, one for final volume, and one for calculated percentage change.

If it is desired to make specific gravity or weight-change determinations on the same apparatus, this Jolly balance may be further modified as shown in Fig. 4. Mounted parallel to the adjustable volume scale is a second transparent scale whose divisions run in the opposite direction, that is, from zero at the upper end to about six at the lower end. This second tape need be adjustable only over a range of a few centimeters so that the zero point may be set to coincide with the position of the sighting disk when the support hook, but no sample, is hanging from the spring.

The weight of the sample in air can be read from this second tape opposite the zero point of the adjustable volume scale and may be made either at the time the zero point is being set or after the volume determination is finished. The mirror image may be shifted from one side of the sighting disk to the other and hence, by proper location of the transparent scales, from one scale to the other merely by a slight shift in the operator's position or by the alternate use of one eye or the other.

Comparisons with analytical balance results have shown volume determinations made on this apparatus to be accurate within 0.01 cu. cm., while the average deviation of the final percentage change in volume has been less than 0.2 per cent on the samples compared. This inherent error has been found in the Chicago Rawhide laboratories to be smaller than the normal expected deviation between duplicate determinations on the same compound or between duplicate batches, and in the ordinary laboratory work of developing and controlling rubber stocks is more than compensated for by a significant saving in time.

Acknowledgment:

Acknowledgment is made of the contributions of the staff of the Engineering Department of the Chicago Rawhide Manufacturing Co., who cooperated closely in the design and construction of the Jolly balance and who made the drawings included in this paper.

Bomb Oxidation Tests of Grease and Storage Life of Grease-Lubricated Mechanisms[1]

By H. Gisser[2] and F. L. Meshkov[2]

SYNOPSIS

This paper presents the results of experimental work begun in 1942 to correlate the Norma-Hoffmann bomb-oxidation test with the behavior of instrument grease in stored mechanisms.

It was found that for lithium-base greases of the AXS-637 type, bomb-oxidation data order the greases the same as storage behavior. Numerical factors have been calculated relating storage failure of lubricants at 75 C. with induction period in the bomb test on copper catalyst. The correlations established do not hold for sodium-base greases, but it is not known whether this is due to the change in metal soap or to differences in volatility.

The bomb oxidation appears to follow the Arrhenius temperature rate equation, and temperature coefficients for bomb oxidation are given.

Calculations and conclusions are based on available data. Bomb-oxidation tests and storage at lower temperatures are still in progress.

THE Norma-Hoffmann bomb-oxidation test for grease was described before the Society in 1938 (1).[3] Since that time its use as an aid in predicting the "shelf life" of grease in lubricated mechanisms has become quite common and it is now specified in many Army and Navy Specifications. A great deal of work has been done on standardization of test conditions and determination of reproducibility in different laboratories, during which it was demonstrated that rigid adherence to detail is essential for reproducibility. On the other hand, little work has been done on correlation of bomb-oxidation data and length of serviceability of grease in lubricated parts.

It has been recognized for several years that bomb-oxidation data bear little relation to service life of grease unless the lubricated parts are in a static condition (that is, in storage), which may readily be seen since exercising moving parts tends to retard the deleterious effect of oxidation products, and physical or other breakdown of the grease generally occurs before the effect of oxidation products becomes evident in active service. Except for the above, the relationship between bomb-oxidation data and oxidative breakdown of grease in service is not clearly understood. The use of the bomb-oxidation test in specifications has been predicated on the assumption that a highly stable grease is required for some applications (for example, instruments). In addition, it is the only available method of determining oxidation stability of grease.

As an approach to a better understanding of grease oxidation and its relation to service life under static conditions, experimental work was undertaken to establish a correlation between bomb-oxidation data and shelf life of lubricated mechanisms. This work was planned to include storage at several temperatures to determine the feasibility of extrapolating accelerated storage data to ambient temperatures. Since exposure of the grease to elevated temperature involves volatilization of one or more components, relative volatility of the grease at the storage temperatures was determined as an aid in interpreting the experimental data.

This paper contains the data obtained over a three-year storage period.

EXPERIMENTAL PROCEDURE

Materials:

The greases used in this work were obtained from commercial sources and are described below:

A—Sodium base, calcium secondary base, no oxidation inhibitor.
B—Sodium base, calcium secondary base, no oxidation inhibitor.
C—Lithium base, iron secondary base, containing an oxidation inhibitor.
D—Lithium base, iron secondary base, containing an oxidation inhibitor.
E—Lithium base, lead secondary base, containing an oxidation inhibitor.
F—Lithium base, containing an oxidation inhibitor.

Greases C to F are intended for low-temperature applications and contain volatile fractions. These greases are the type recommended for instrument lubrication and were selected for that reason. Greases A and B were used as examples of low and moderate stability materials. They contain considerably less volatile material than the lithium-base greases.

The instrument mechanisms used were No. 204 ball bearings having brass retainers and typical steel worm and bronze wheel movements. These are illustrated disassembled in Fig. 1.

Bomb-Oxidation Tests:

The apparatus used in this test has been previously described (1). The following procedure was used:

Initial oxygen pressure: 110.0 ± 0.5 psi.
Weight of sample: 20.0 ± 0.1 g. distributed among five glass dishes.
Procedure for charging the bomb with oxygen: The bomb was charged to a pressure of 95 psi. at room temperature and then placed in the constant temperature bath. After 2 hr., the pressure was relieved until it was 110.0 ± 0.5 psi.
Preparation of catalyst: Electrolytic copper strips, 1.75 by 0.25 by 0.02 in., were bent at a 45-deg. angle and then dipped for 60 sec. in 40 per cent nitric acid at room temperature. The strips were washed with cold tap water, cold distilled water, and cold ethyl alcohol, and then dried in a desiccator over calcium chloride.

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[1] Published with the permission of the Chief of Ordnance, Army Service Forces.

[2] Chemist, Ordnance Laboratory, Frankford Arsenal, Philadelphia, Pa.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

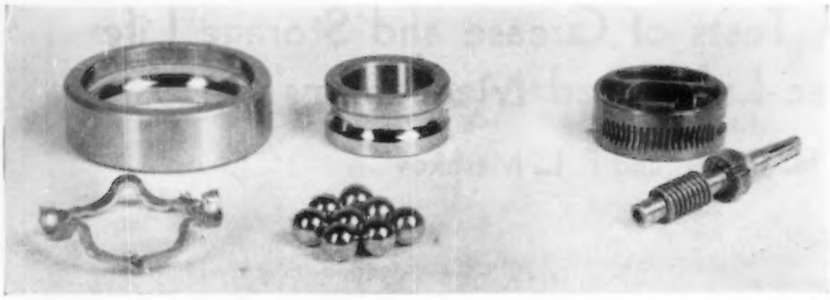


Fig. 1.—Disassembled Test Specimens.

Tests were run with and without copper catalyst. In the former, one copper strip was placed in each of the five test dishes. Both catalyzed and uncatalyzed tests were run until an induction period (I.P.) was reached, or until a pressure drop (P.D.) of 50 psi. had been obtained. The pressure drop was plotted against the time, and the resultant graphs used for the comparison of data. No tests were run on the grease after the oxidation was completed. Tests on all of the greases were run at 100.0 ± 0.2 C., 85.0 ± 0.2 C., and 70.0 ± 0.2 C. All tests were run in duplicate.

The induction period was calculated by the following method: The horizontal and vertical parts of the curve were extended, and the angle formed by these lines was bisected. The abscissa of the intersection of the bisector and the curve was taken to be the end of the induction period.

Storage Tests:

Four instrument mechanisms and seven bearings were used for each grease at each temperature. The rust preventive compound was removed from the ball bearings with mineral spirits followed by petroleum ether. The bearings were then dried in an oven at 70 C. for 15 min. and lubricated with 1.5 ± 0.2 g. of grease by working the lubricant in with the fingers while the bearing was spun on a motor drive shaft. When this was completed, the bearing was rotated for 1 min. in each direction (outer race fixed) at 1800 rpm. The instrument movements were lubricated in the manner regularly used in the Frankford Arsenal Instrument Division Assembly Shop. Storage tests were conducted at the following temperatures: 40.0 ± 1.0 C., 50.0 ± 1.0 C., 75.0 ± 1.0 C., 100.0 ± 1.0 C.

Observations were made at intervals of one week to one month for movements stored at 75 and 100 C., depending on the temperature of storage and the grease used. Longer intervals elapsed between observations on the assemblies stored at lower temperatures.

Observations on the bearings were made in the following manner: The inner race was secured and the outer race rotated by hand the minimum amount necessary to determine the state of the motion. In no case did this exceed one fourth of a revolution, and it was usually possible to limit the rotation to one eighth of a revolution. The bearings were so stored that material bled from one bearing did not flow onto another. Observations on the instrument movements were made in a similar manner, that is, the motion was limited to the minimum necessary to determine the state of motion. The ease of bringing the movement to a predetermined setting was considered. Two criteria of failure were used: the first was when the part showed gritty motion, the second when the part showed very stiff motion.

After storage, the parts were disassembled, and the lubricant residue and metal surfaces examined for determination of the nature of the residue or evidence of corrosion.

Volatility:

A sample of grease weighing 1.25 ± 0.25 g. was placed in a glass grease test dish ($1\frac{1}{2}$ in. in diameter by $\frac{9}{32}$ in. high). The dish was placed in a gravity convection oven for 96 hr., the thermometer bulb being at the same level of the oven as the test dish. The percentage loss in weight was calculated as volatile matter. All determinations were run in quadruplicate. Tests were conducted at 100.0 ± 1.0 C. and at 75.0 ± 1.0 C.

Results

Experimental Data:

The bomb-oxidation data are summarized in Table I and illustrated in Fig. 2. The storage data are summarized in Table II. With few exceptions, bomb-oxidation tests have been completed at all temperatures except at 70 C. without catalyst. Volatility data have been included in Table II for convenient reference. Storage tests at 100 and 75 C. have been completed, but only isolated data at 50 C. are available.

In Table III the greases are ar-

TABLE I.—BOMB-OXIDATION DATA.

Grease	Temperature, deg. Cent.	No Catalyst		Copper Catalyst		
		Induction Period, hr.	Pressure Drop per 100 hr. During Induction Period, psi.	Induction Period, hr.	Pressure Drop per 100 hr. During Induction Period, psi.	Pressure Drop per 100 hr.[a]
A	100	none	65 (90)[a]	none	..	101 (50)
	85	95	5.0	none	..	55 (100)
	70	295	1.4	55	1.9	
B	100	185	4.5	none	..	39 (140)
	85	915	1.3	100	2.5	
	70	..	..	305	1.1	
C	100	690	2.0	160	2.5	
	85	2000+	0.70[b]	690	1.6	
	70	..	..	1200+	0.33[d]	
D	100	375	1.9	70	4.8	
	85	670	1.3	320	0.90	
	70	..	..	885	0.63	
E	100	70	3.0	none	..	117 (50)
	85	440	1.0	120	1.8	
	70	..	..	400	0.65	
F	100[c]	none	33.2 (208)[a]	none	..	173 (40)
	85	..	..	none[c]	..	78 (72)
	70	..	..	55[c]	4.0	

[a] Linear change with immediate breakdown. The number in parentheses indicates the length of test in hours.
[b] Linear change during 2000 hr.
[c] Single determination.
[d] Based on 1200 hr.

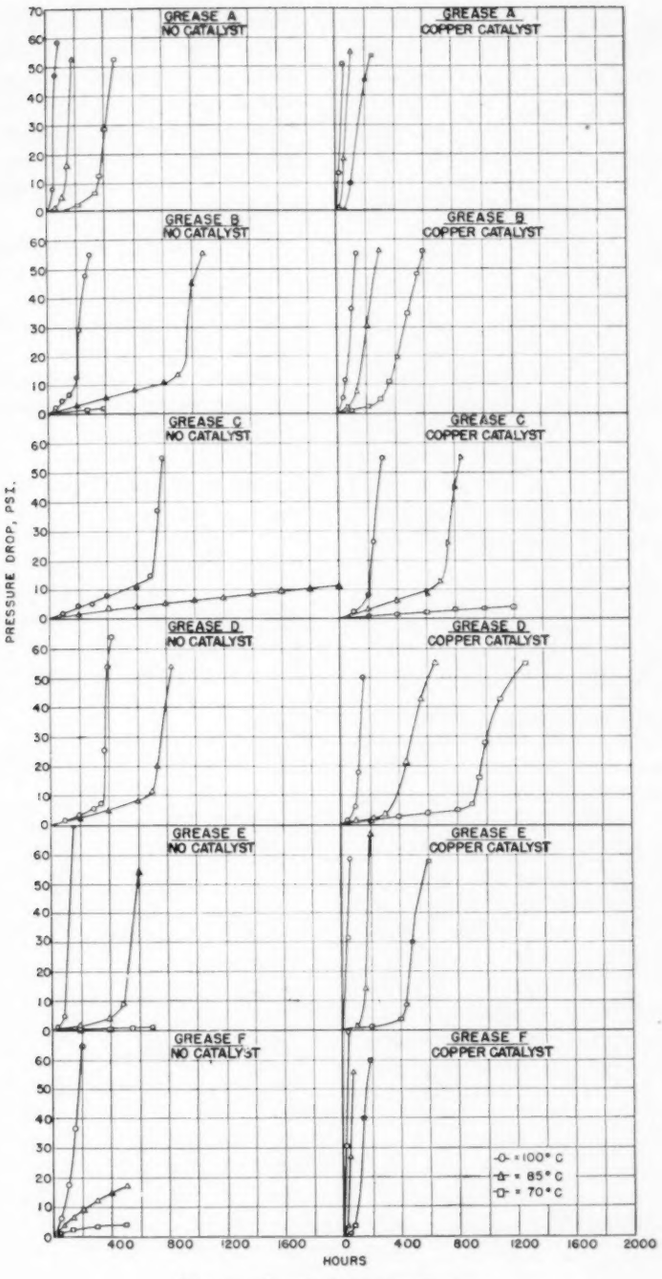


Fig. 2.—Bomb-Oxidation Data.

ranged in order of merit in accelerated oxidation, volatility, and storage. In preparing this table the data were subjected to statistical analysis to determine whether differences obtained were significant (2). Greases bearing different order numbers (in the same column) in Table III were significantly different at the 5 per cent level (3). On the other hand, in several instances greases bearing the same order numbers were significantly different. This arose from the peculiar circumstance that occasionally a series of three or more greases behaved in such a way that the first was not significantly different from the second, and the second was not significantly different from the third. These greases were all ordered by the same number, but to indicate where there are significant differences, letters denoting significantly different greases having the same order number were placed next to the order number. In Table III, therefore, when a letter appears next to an order number, the grease bearing the order number is significantly poorer than the grease denoted by the letter. For example, in the column for P.D., no catalyst, Bomb Oxidation Test, sample B was significantly different from C and D but not from E.

Discussion:

After storage, the steel surfaces of the specimens were found to be uniformly pitted and solution of copper was evidenced by green stains and deposits. This was to be expected in view of the advanced state of oxidation of the lubricants. The lubricants were generally semi-solid or practically solid in nature and contained gummy and varnish-like material.

The Norma-Hofmann bomb-oxidation test as currently used for specification testing provides essentially empirical data. No attempt is made to analyze the sample for products of oxidation during the oxidative process. It is reasonable to believe that the oxidative process with lubricants of different composition may be different in nature. The induction period and pressure drop rate, either or both of which are generally taken as an index of oxidation rate, are therefore empirical quantities deduced from pressure *versus* time curves. The intention of this work was to determine whether these empirical quantities could be correlated with behavior of the lubricant in stored mechanisms.

Failure of lubricated mechanisms in storage may be due to a number of factors, the most important of which are oxidation of the lubricant, corrosion of the metal parts because of a corrosive atmosphere (corrosion due to oxidation products may conveniently be considered as oxidative failure), and volatilization of light fractions of the lubricant with resulting increase in viscosity. Volatility is of particular importance in view of the method used to determine unserviceability. The storage conditions were such that the relative humidity was low and atmospheric corrosion would therefore not be of importance in this work. Table III shows that the sodium-base greases (A and B) are uniformly better in storage than the lithium-base greases, and Table II

indicates that they are also less volatile. It appears therefore that the difference between the sodium- and lithium-base greases may be due to volatility. On the other hand, in one instance grease C, although less volatile, is better in storage than grease A. Since there are no reversals of this order, it appears that the difference in behavior of the sodium- and lithium-base greases may be due to either differences in volatility or in oxidative behavior. The data on greases A and B (instruments at 100 C.) support either possibility. It is anticipated that storage at lower temperatures will not be affected as much by volatility of the lubricant, and this point may therefore be clarified when storage data at 40 and 50 C. become available. In any event, the discussion will be limited to the lithium-base greases.

Correlation.—It is of interest to note that there are practically no reversals of order of merit in the bomb-oxidation data at any of the three temperatures, either with or without catalyst. There is only one exception, grease F being better than grease A in the pressure-drop rate at 100 C. without catalyst. These data are therefore insufficient to determine whether induction-period or pressure-drop rate should be used as an empirical index of oxidation stability in the Norma-Hoffmann test. On the other hand, induction-period data do seem to differentiate greases better than pressure-drop data. In spite of this better differentiation, it is desirable that specification of maximum pressure-drop rate and minimum induction period be continued.

It will be noted from Table III that, except for grease F (and grease D in one instance), there are no reversals in order of merit among the storage data and bomb-oxidation data. The anomalous behavior of grease F compared with grease E may be due to its lower volatility. There is no apparent explanation for the reversal in order between greases D and F in the stored bearings at 100 C.

Temperature Coefficients.—The bomb-oxidation data provided at most three points from which to calculate temperature coefficients. For induction periods, in only two instances were three points available and these were found to lie on the straight line:

$$\log (\text{I.P.}) = A - \frac{B}{T} \quad \ldots\ldots (1)$$

where A and B are constants and T is the absolute temperature, log I.P., and $1/T$ being considered the variables. The quantity, $-B$, which is the slope of the line, represents the

TABLE II.—STORAGE DATA.

Grease	Temperature, deg. Cent.	Volatility, per cent		Average Time for Failure, days							
				Instruments[d]				Bearings			
				Gritty Motion		Very Stiff Motion		Gritty Motion		Very Stiff Motion	
		Mean	σ[a]	Mean	σ	Mean	σ	Mean	σ	Mean	σ
A	100	2.195	0.167	95	11	303	84	139	21	186	26
	75	1.115	0.018	568	131	811	47	200	0	280	34
B	100	0.844	0.091	210	67	381	109	143	24	193	35
	75	0.634	0.026	421	0	786	23	200	0	281	31
	50	....	....	..	..	..	..	673[c]	123	..	..
C	100	8.381	0.552	142	14	415	47	16	7	78	18
	75	3.381	0.548	392	58	531	32	182	31	263	0
D	100	17.01	1.01	24	4	219	7	7	0	11	5
	75	4.305	0.588	347	71	521	73	85	0	193	74
	50	....	....	718[b]	..	..	..	..	..	..	..
E	100	33.38	2.24	22	0	157	24	7	0	29	10
	75	13.60	0.627	138	53	545	43	29	0	118	56
	50	....	....	718[b]	..	..	..	821	62	..	..
F	100	24.44	0.593	29	0	356	51	15	8	27	5
	75	6.929	0.475	98	30	484	0	68	51	170	64
	50	....	....	709	110	..	..	428	80	498	149

[a] σ = standard deviation.
[b] One instrument failed, three still in storage.
[c] Three bearings failed, four still in storage.
[d] Steel worm and bronze wheel movements.

TABLE III.—COMPARATIVE ORDER OF FAILURE.[a]

Grease	Bomb-Oxidation Test								Volatility, per cent	Instrument Failure		Bearing Failure	
	No Catalyst				Catalyst								
	I.P.		P.D.		I.P.		P.D.			Gritty	Very Stiff	Gritty	Very Stiff
	100 C.												
A	5		3		3		4		2	2	1	1	1
B	3		1-DC		3		3		1	1	1	1	1
C	1		1		1		1		2	1	1	2	2
D	2		1		2		2		4	3	1-CBF	3	5
E	4		1		4		4		6	3	2	3	3
F	5		2		4		5		5	3	1	2	4
	85 C.		70 C.		85 C.		70 C.		75 C.				
	I.P.	P.D.	I.P.	P.D.	I.P.	P.D.	I.P.	P.D.					
A	3	1-CE	..	..	4	3	5	1-CDE	2	1	1	1	1
B	2	1	..	..	3	2	4	1-C	1	1	1	1	1
C	1	1	..	..	1	1	1	1	3	1	2	1	1
D	2	1	..	..	2	1	2	1	3	1-A	2	2	2
E	2-B	1	..	..	3	1-D	3	1	5	2	2	2-D	2
F	..	..	..	..	4	4	5	2	4	2	2-E	2	2

[a] 1 = best.
2 = next best, etc.

NOTE: A letter following any order number indicates that the grease denoted by the letter is significantly better than the grease bearing the order number. The greases were put in the same order because there is at least one grease not significantly different from either.

temperature coefficient. On differentiating:

$$\frac{1}{\text{I.P.}} \times \frac{d(\text{I.P.})}{dT} = \frac{B}{T^2} \quad \ldots\ldots (2)$$

the percentage change in induction period may be calculated at any desired temperature.

It will be noted that this is in good agreement with the Arrhenius equation (3):

$$\frac{d \log K}{dT} = \frac{E}{RT^2} \quad \ldots\ldots (3)$$

where K is reaction rate, T is absolute temperature, R is the gas constant, and E is a constant (a term involving energy). The induction period is in the nature of a reciprocal of reaction rate, being the time for specific change to take place.

It was assumed that all of the bomb-oxidation data behaved in accordance with Eq. 1 above, although data were available at only two temperatures in most instances, and temperature coefficients were calculated. The data are given in Table IV. It is of interest to note that the

TABLE IV.—TEMPERATURE COEFFICIENT OF INDUCTION PERIOD.

Grease	$B = T^2 \frac{d(\log \text{ I.P.})}{dT} \times 10^{-3}$	
	No Catalyst	Catalyst
A	3.9	...
B	6.1	3.7
C	4.3	3.7
D	4.4	4.7
E	7.8	4.8

temperature coefficients are of the same order of magnitude. Although this may be accidental in view of the limited data, the good agreement obtained in the copper-catalyzed oxidations indicates that this temperature coefficient may be used for lithium-base greases of the AXS-637 type. Further data are desirable, however, before attempting to attach any theoretical significance to the data.

Similar calculations were made with the pressure-drop data, but in most instances the data did not fit a curve of the form

$$\log \text{P.D.} = A - \frac{B}{T}$$

On the other hand, if some other relation existed between the pressure-drop rates and temperature, it would be expected that when a straight line was fitted to two of the points (log P.D. *versus* $1/T$), the third point would consistently lie on one side or the other of this line. This was not found to be the case and the poor fit is therefore probably due to experimental error. Large errors in pressure-drop data are to be expected in view of the short induction periods at 100 C. Where the induction period at 100 C. was zero, the pressure-drop rates represent rapid oxidation and cannot be expected to follow the same temperature relationship as pressure-drop rates during the induction period.

It has previously been pointed out that volatility of the lubricants was an important factor in determining failure of the specimens at the elevated temperatures at which data are available. The time for failure represents that time at which the combined effect of increase in viscosity due to volatilization, formation of polymers due to oxidation, poor lubrication due to formation of metallic soaps binding the metal surfaces, and poor lubrication due to corrosion of the metal surfaces by products of oxidation results in either gritty or stiff motion. The volatilization effect is not a chemical reaction and would not be expected to follow the Arrhenius equation, but would depend on the vapor pressure distribution of the base oil in the grease at the temperature of storage. Calculation of temperature coefficients, assuming the straight-line relationship, yields results that are of different orders of magnitude.

were performed on greases C, D, and E (lithium-base) for storage at 75 C. against induction period with copper catalyst. These factors are given in Table V and represent days' storage life at 75 C. per hour of induction period with copper catalyst. The correlation factors include the effect of volatility. In the absence of temperature-coefficient data for storage failure, it is not possible to calculate storage life at lower temperatures. Factors for grease F are not given because of the anomalous behavior exhibited by this grease. It is important to note that the factors given in Table V may no longer be valid if the composition of the grease be materially altered, such as a change from a petroleum-base fluid to a synthetic material.

Table V indicates that the correlation factors for any one temperature of the bomb-oxidation test and one type of failure are with few exceptions of the same order of magnitude. It will be noted that these factors are generally doubled from grease C to grease D for the instrument assemblies, although again there are exceptions.

The data presented are in the nature of a progress report since the storage and bomb-oxidation tests are still in progress. Correlation factors for storage at elevated temperatures are of interest but of little practical value because these temperatures are not normally used for storage. It is anticipated that the data to be obtained from storages at

TABLE V.—CORRELATION FACTORS IN STORAGE LIFE IN DAYS AT 75 C. PER HOUR OF INDUCTION PERIOD, WITH COPPER CATALYST.

Grease	Instruments		Bearings	
	Gritty Motion	Stiff Motion	Gritty Motion	Stiff Motion
Bomb-Oxidation Test at 100 C.				
C	2.45	3.32	1.14	1.65
D	4.96	7.44	1.04	2.76
Bomb-Oxidation Test at 85 C.				
C	0.52	0.77	0.26	0.38
D	1.08	1.63	0.23	0.60
E	1.15	4.54	0.24	0.98
Bomb-Oxidation Test at 70 C.				
D	0.39	0.59	0.096	0.218
E	0.35	1.36	0.073	0.295

Prediction of Storage Life From Bomb-Oxidation Data.—The goal of correlation between service life and accelerated test data is the prediction of the former from the latter. The data obtained permit the required factors to be calculated in several instances. Such calculations 40 and 50 C. will permit useful factors to be obtained and that these data may not be so affected by volatilization of the lubricant as those given in this report. If this is so, it will be possible to calculate temperature coefficients for storage failure.

The greatest error in the experimental work was the method used to determine storage failure of the mechanisms. Although these observations were made by the same individual, they extended over a 2-yr. period, and it is surprising that the variances were as low as were found. It is desirable that the observations be made with an instrument, eliminating the personal factor, and that the measurement be related to the degree of poor motion which would actually constitute failure for a particular instrument in service. Special equipment to enable solution of the former is under study, while the latter may be answered only after considerable experience with the mechanisms in actual use.

Conclusions

1. The Norma-Hoffmann bomb-oxidation test for grease orders lithium-base greases of the AXS-637 type in the same way as storage failure at 75 C.

2. Numerical factors have been calculated to enable prediction of storage life of AXS-637 type grease from bomb-oxidation data. These factors include the effect of volatility.

3. Bomb-oxidation data on the greases tested apparently obey the Arrhenius equation. Temperature coefficients of induction period for the greases are given.

References

(1) F. L. Wright and H. A. Mills, "Some Applications of an Accelerated Test for Determining the Chemical Stability of Lubricating Greases," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 525 (1938).

(2) P. R. Rider, "An Introduction to Modern Statistical Methods," John Wiley and Sons, New York, N. Y., Chapter VI (1939).

(3) F. H. Getman and F. Daniels, "Outlines of Theoretical Chemistry," John Wiley and Sons, New York, N. Y., p. 332 (1937).

New Apparatus for Film Testing[1]

By C. Howard Adams[2]

A new type tension testing machine has been developed by Fabric Research Laboratories, Boston, Mass. This apparatus was designed primarily for evaluation of textiles. A rather unique weighing system was devised to cover the wide range of strength values encountered in such materials, that is, single fibers to woven fabrics or ropes. It is capable of accurately measuring the load applied to a specimen whether it be 50 g. or 50 lb. This is accomplished by attaching the upper specimen grip to one end of a cantilever beam, the other end being securely attached to the bed of the machine by a vise. Metalectric strain gages attached to the cantilever measure deflection, which is kept within the elastic limit of the beam material. Deflection is translated into load and recorded on an Esterline-Angus recording galvanometer in a d-c. bridge circuit. The load range of the machine is determined by the cantilever beam used. The load-application system is very similar to that of the Scott L-5 Rubber Tensile Tester. It is possible to vary the jaw-separation rate as follows: 3, 6, and 12 in. per minute. The recorder chart moves at a speed corresponding to jaw-separation rate. Consequently, a continuous record of load *versus* jaw-separation distance is obtained.

Through the courtesy of W. J. Hamburger, Fabric Research Laboratories, Boston, Mass., some work of a preliminary nature was carried out with this new apparatus on 0.010-in. cellulose acetate film. For each specimen a well-defined upper yield point was observed, the value of which increased in an essentially linear manner with jaw-separation rate. The ultimate strength also increased with increasing speed of testing, though at a slower rate than the upper yield point. It is surmised that at a sufficiently high testing speed, the upper yield and ultimate strength values would become the same. The energy-to-fracture, as obtained by integration of the load *versus* jaw-separation curve, showed no apparent trend with testing speed. True elongation was measured by means of dividers and evidenced little, if any, trend with speed of testing. Comparative tests on the same material were carried out with the Scott IP-4 tilting table tester at a loading rate of 40,000 psi. per minute (based on original cross-section). In general, the IP-4 strength values were higher than those obtained with the new apparatus, by about 10 per cent. Energy-to-fracture values were greater by essentially the same factor. This difference may be accounted for by: (1) difference in method of loading (constant rate of loading *versus* constant rate of jaw separation), (2) difference in test atmospheres (Scott Tester, 77 F., 50 per cent relative humidity; Fabric Research Laboratories Tester, 70 F., 65 per cent relative humidity).

The Fabric Research Laboratories testing machine should prove to be of interest to those concerned with film tension testing.

The author is indebted to J. M. Calhoun, Eastman Kodak Co., for bringing this apparatus to our attention.

[1] Summary of talk given before Subcommittee VIII on Research, of A.S.T.M. Committee D-20 on Plastics, March 7, 1946, at Atlantic City, N. J.

[2] Research Dept., Monsanto Chemical Co., Plastics Div., Springfield, Mass.

High-Temperature, High-Speed Testing of Lubricating Greases[1]

By J. F. Macphearson[2]

THIS paper will deal with the testing of greases under conditions approximating those encountered in actual service. The actual apparatus to be lubricated is the test machine and the length of operation is approximately the service life of the machine itself. The accuracy of evaluations by this method will depend on the number of tests made.

The Army Air Forces and the Navy Bureau of Aeronautics instituted a grease-testing program in an effort to obtain the best possible grease for aircraft engine accessories. The Services invited engine-accessory manufacturers to participate in this program to forestall any possible objection to the greases specified. Twelve grease samples were forwarded for test to the Aircraft Generator Section, Motor Engineering Div. at the River Works of General Electric Co. at West Lynn, Mass. Although the selection of greases from this group for aircraft-generator lubrication was the primary consideration, other objectives were added when the value of the work became more apparent.

The final objectives of the testing program were as follows:

1. To determine the best possible grease for the lubrication of aircraft generators.
2. To study the correlation between operating characteristics and chemical and physical properties of a grease.
3. To study by accelerated tests the effects produced by the addition of an antioxidant to grease.
4. To determine the lubricating value of unconventional types of greases such as those made from silicone oils or synthetic oils of the petroleum class.

Description of Operating Conditions:

Aircraft generators may be required to operate up to 1000 hr. without regreasing. During this period, bearings may operate at temperatures as high as 140 C. (285 F.), while at high altitudes, the cooling air may reduce the commutator-end bearing to as low as −20 C. (−4 F.). Generators must be able to start at temperatures of −55 C. (−67 F.) without damage to the machine.

Apparatus:

Five aircraft generators were set up as shown in Fig. 1 and operated as d-c. motors. Each machine has individual controls and safety devices. Heat is applied to the bearings by means of Calrod heaters, as shown in Figs. 2 and 3. The control of the heater voltage permits close and independent control of bearing temperatures. These temperatures are measured by thermocouples placed against the middle of the outer race of each bearing. Figure 4 shows the transfer connections, selector switches, and thermocouple bridge used in the temperature measurements. The bearings are the same as those normally used in this type of generator. The commutator end has a single shielded No. 203 ball bearing and the drive end a single shielded No. 205 bearing, both conforming to ABEC-1 tolerance standards.[3]

First Tests:

Originally the machines were operated at a speed of 10,000 rpm. with bearing temperatures held at 150 C. (300 F.). It was found after a very few tests that none of the greases tried would operate at this temperature long enough for ac-

[3] Annular Bearing Engineers Committee.

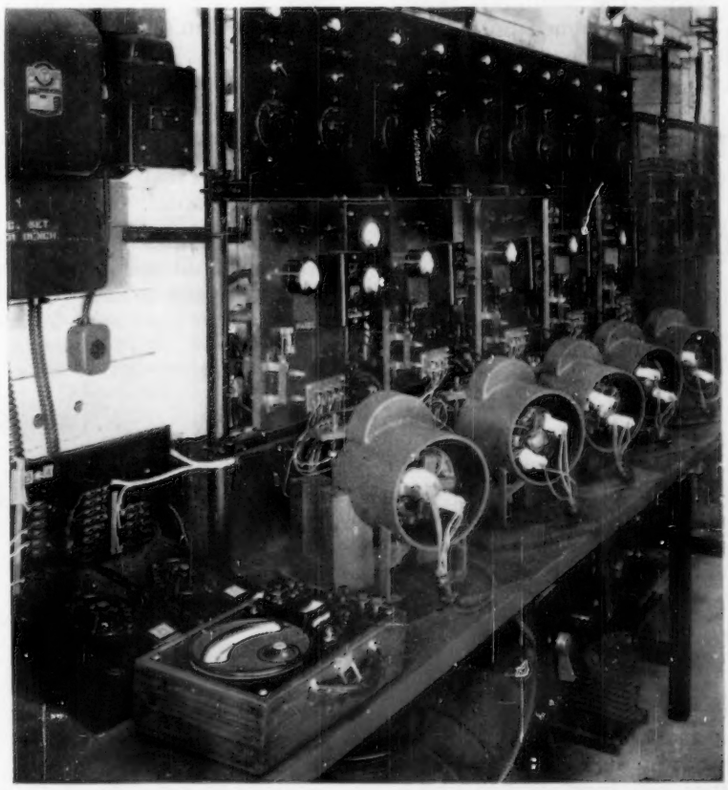


Fig. 1.—Aircraft-Generator High-Speed, High-Temperature Grease Test.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Paper presented at a meeting of Technical Committee G of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants, held in Cleveland, January 14, 1946.

[2] Lynn Motor Section, General Electric Co., River Works, West Lynn, Mass.

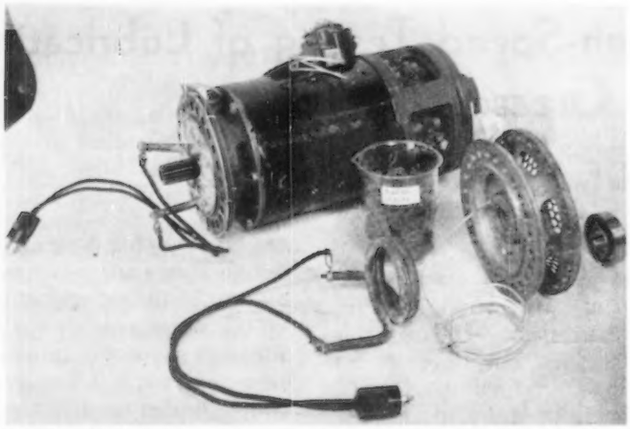


Fig. 2.—G-E Aircraft d.-c. Generator, and Drive-End Bearing Heater, for High-Speed High-Temperature Grease Test.

curate evaluation. Since the purpose was to determine the suitability of various greases for aircraft-generator lubrication, generator service conditions were reviewed and a test procedure established to approximate generator heating conditions.

Procedure

The machines are accordingly now operated on 24-hr. cycles, comprised of 20-hr. operation at 10,000 rpm. and 4-hr. shutdown, with no heat applied to the bearings during the shutdown period. The test is continued until failure occurs, using the following procedure:

1. One cycle of operation with no heat applied to the bearings.
2. Ten cycles with bearing temperatures held at 90 C. (195 F.).
3. Ten cycles with bearings at 120 C. (250 F.).
4. Ten cycles with bearings at 130 C. (265 F.).
5. Twenty cycles with bearings at 140 C. (285 F.).

If, at the end of the last 20 cycles after 1020 hr. of actual operation, the bearings are still in operating condition, they are washed out and relubricated. The test is then restarted and allowed to operate on the same 24-hr. cycle until failure, maintaining bearing temperatures at 150 C. (300 F.).

Failure of the bearings is indicated as follows:

1. An increase in bearing frictional torque 100 per cent above the normal operating torque. (The operator can determine when this condition has been reached by observing a line-current ammeter in the circuit of the test machine.)
2. A sudden rise in bearing temperature amounting to 20 C. (68 F.) above normal within a 30-min. period.
3. An increase of vibration of 3 mils above the starting vibration or a sudden pronounced increase in the noise level of the machine.

Conditions of Test:

The bearings and housings are filled approximately one third full of grease. The quantity of grease used is weighed and the same weight used in all other tests on the same grease. For conventional type greases, this amount is approximately 9 g. for the No. 205 ball bearing and 4 g. for the No. 203 bearing.

Test Data Charts:

The test data charts include recordings of all pertinent data obtained on each grease. It should be noted that the time-temperature cycle was changed in some instances. Usually this was done on greases not considered suitable for high-temperature operation. Sometimes this was done merely to increase or decrease the severity of the test. The test-summary charts give at a glance the maximum, minimum, and average results obtained from valid tests. The notes at the bottom of the sheet show information not included on the chart. The sheet on physical and chemical properties indicates pertinent information about the oil and soap and such physical properties as a temperature-penetration curve and bleeding and evaporation rates *versus* temperature. Oil viscosity on these sheets is given in Saybolt units.

Interpretation of Results

There are three stages to work of a research or developmental nature:

1. Establishment of facilities,
2. Conduct of the investigation, and
3. Interpretation of results.

The most discussion and greatest difference of opinion will develop on the third stage. Results have been studied and the more obvious conclusions drawn. As a possible aid to the further interpretation of results, a theory in mathematical form is given. It should be understood that this is presented only to provoke thought on the subject. Tests were not considered valid where dirt was found present in the ball bearing, or when misaligned or distorted ball bearings were discovered. Other tests were considered invalid where five or six tests operated for

Fig. 3.—G-E Aircraft d.-c. Generator, and Commutator-End Bearing Heater, for High-Speed, High-Temperature Grease Test.

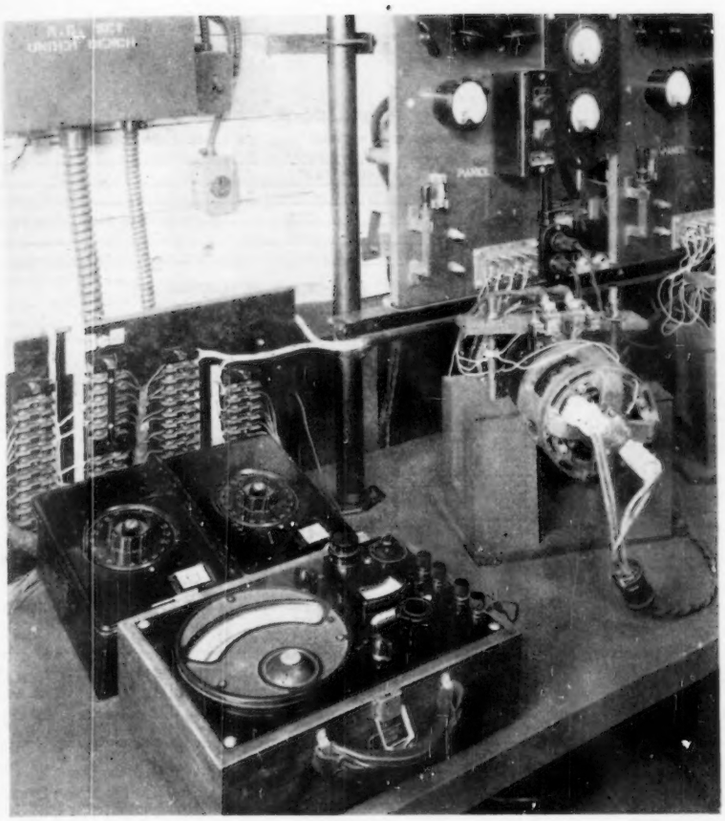


Fig. 4.—Temperature Measuring Equipment for Aircraft-Generator High-Speed, High-Temperature Grease Test.

a fairly consistent period of time and one test taken under similar conditions failed in a ridiculously short time. These tests which are considered invalid will depend entirely upon the judgment of the person making the tabulations and the decision can be made only when the balance of test data is available.

Mathematical Approach to Problem

In attempting to find a mathematical approach to the problem of lubrication life we based our work on the following assumptions:

1. All ball bearings are fluid-lubricated. In so-called grease-lubricated bearings, the grease serves as a reservoir for the lubricant.

2. The optimum quantity of lubricant C delivered to the bearing in time t is that quantity resulting in the lowest bearing-temperature rise.

Nomenclature and Development of Formulas:

t = unit of time,

C = optimum quantity of lubricant delivered,

$C/t = Q$ = optimum rate of use of lubricant,

T = total lubrication life,

W = total weight of grease,

PO = per cent of W which is lubricant,

O = Available lubrication from W pounds of grease,

$O = W \cdot PO$

HF = Housing factor or an efficiency number denoting that portion of lubricant freed from the grease which is actually delivered to the bearing,

BR = bleeding rate,

ER = evaporation rate,

$$f(Q) = \frac{W \cdot PO \cdot HF}{T},$$

$$T = \int \left(\frac{W \cdot PO \cdot HF}{Q} \right) \quad \ldots\ldots (1)$$

$$BR = \frac{W \cdot PO}{W \cdot T} = \frac{PO}{T}$$

$$BR = \frac{Q}{W \cdot HF}$$

and

$$BR - ER = \int \frac{Q}{W \cdot HF} \quad \ldots\ldots (2)$$

Several points about Eqs. 1 and 2 are significant. If combined they will eliminate W, HF, and Q and thus tell us nothing of the critical point of lubrication, the effects on lubrication life of housing design, and the total weight of grease. Also Q, HF, and W are essentially constant for one set of conditions. Q will vary according to several things: thermal capacity, oiliness, viscosity, and viscosity index. For one set of conditions these values may be independent of time. BR and ER have been shown by experiment to vary with time. They also are dependent upon other factors which do not affect Q. Equation 1, we see, has not considered BR and ER. It shows the maximum life obtainable for a given weight of grease, containing a given percentage of lubricant, operating in one housing. Q is an optimum rate and not the rate which is likely to occur.

With these considerations in mind, some abstract interpretations may be made of the results obtained. Whether these are true will be determined by future work on the subject.

Summary and Conclusions

On the basis of tests conducted, a grease was selected for aircraft-generator lubrication which has performed very satisfactorily in service. Records show that bearing life has been materially increased with the use of this grease. This grease, selected by functional tests, would not have been selected for application on aircraft generators by previous methods of grease evaluation. Other greases which were perfectly satisfactory, according to the physical and chemical means of evaluation, were rejected by the functional tests.

Too high or too low a rate of bleeding and evaporation rates higher than normal appear to have an adverse effect on operating life. Greases such as G-A, G-B, G-C, G-D all have similar bleeding and evaporation characteristics. These greases were among the best of all those tested for high temperature. Conversely, greases such as G-E and G-F which have bleeding rates much higher or much lower than the four former greases yielded much poorer test results.

Tests made on G-G and G-H at

Grease Test Summary

Code: G-A

True Designation:—

Manufacturers Name & Location:—

Sample Received From:—

Test Data

Test	Hours Operated								Total Hrs.	Total Cyc.	R.P.M.	
	120 Hrs. Heat	90°C	100°C	110°C	120°C	130°C	140°C	150°C				
1	20	200			90				320	15	10,000	
2	20	98							118	5	10,000	1
3	20	141							161	8	10,000	1
4	20	200			55				275	13	10,000	
5 (51)	20	96							116	5	10,000	1
6	20	200			140				360	18	10,000	
7	20	200			200	157			577	28	10,000	
8	20	200			200	41			461	23	10,000	
9 (74)	20	200			200	112			532	26	10,000	
10	20	200			200	2			422	21	10,000	
11	20	200			200	200	158		778	38	10,000	
12	20	200			200	67			487	24	10,000	

Test Summary

Temperature Cycle				
90°C	120°C	130°C	140°C	140°C
200 Hrs.	200 Hrs.	200 Hrs.	200 Hrs.	200 Hrs.

Operating Time — Max. Avg. Min.

* First 20 Hrs. Of Operation No Heat Is Applied To Bearings.

1 Test not considered valid

Physical and Chemical Properties

Soap Content Calc. As % Na. Stearate 28 No A Co

Viscosity Oil At 100°F. 667

Viscosity Oil At 212°F. 65

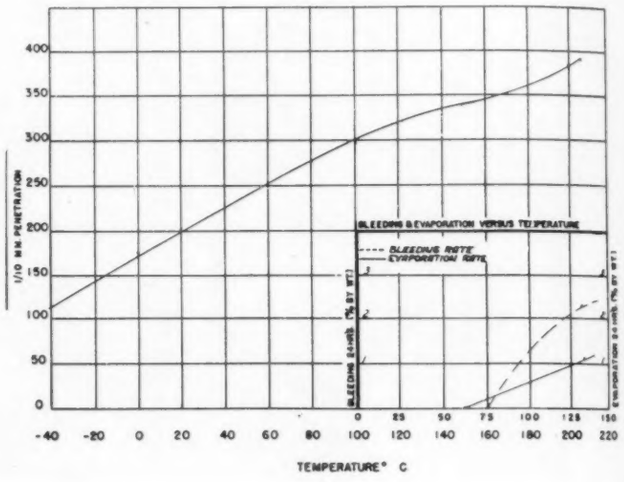
Viscosity Index 65

Specific Gravity At 60°F. 904

Dropping Point °F. 380

Type of Oil Petroleum Conventional Anti Oxidant Base

Consistency Vs. Temperature



Grease Test Summary

Code: G-B

True Designation:—

Manufacturers Name & Location:—

Sample Received From:—

Test Data

Test	Hours Operated								Total Hrs.	Total Cyc.	R.P.M.	
	120 Hrs. Heat	90°C	100°C	110°C	120°C	130°C	140°C	150°C				
1	24	200			200	93			517	25	10,000	
2	20	200			61				281	14	10,000	
3	20	200			194				414	20	10,000	
4	20	200			7				227	11	10,000	
5	20	200			200	12			432	21	10,000	
6	20	200			200	200	61		681	34	10,000	
7	20	200			200	200	105		725	36	10,000	
8	20	200			200	67			507	25	10,000	
9												
10												
11												
12												

Test Summary

Temperature Cycle				
90°C	120°C	130°C	140°C	140°C
200 Hrs.	200	200	200	200

Operating Time — Max. Avg. Min.

* First 20 Hrs. Of Operation No Heat Is Applied To Bearings.

Physical and Chemical Properties

Soap Content Calc. As % Na. Stearate 28 Na

Viscosity Oil At 100°F. 2750

Viscosity Oil At 212°F. 169

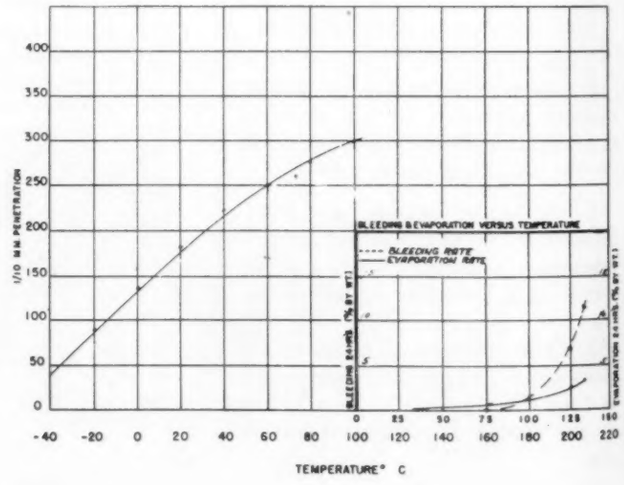
Viscosity Index 102

Specific Gravity At 60°F. 902

Dropping Point °F. 453

Type of Oil Petroleum Conventional

Consistency Vs. Temperature



GREASE TEST SUMMARY

CODE G-C

TRUE DESIGNATION :—

MANUFACTURERS NAME & LOCATION :—

SAMPLE RECEIVED FROM :—

TEST DATA

TEST	HOURS OPERATED								TOTAL HRS.	TOTAL CYC.	R.P.M.	
	NO HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C				
1	20	200			139				359	17	10,000	
2	20	200			116				336	16	10,000	
3	20	200			11				231	11	10,000	
4	20	200			200	200	156		776	38	10,000	
5	20	200			200	200	48		668	33	10,000	
6	20	200			200	200	83		703	35	10,000	
7	20	200			200	200	87		707	35	10,000	
8	20	200			200	200	70		690	34	10,000	
9	20	152							172	8	10,000	1
10	20	200			200	200	156		776	39	10,000	2
11	20											
12												

TEST SUMMARY

TEMPERATURE CYCLE				
90°C	120°C	130°C	140°C	150°C
200 Hrs.	200	200	200	200

OPERATING TIME

MAX. AVG. MIN.

* FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

1 Test not considered valid
2 Duplicate test to #8 received from AE R by auditor this test not included in average

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC AS % NA STEARATE 8% No

VISCOSITY OIL AT 100°F. 1127

VISCOSITY OIL AT 212°F. 76

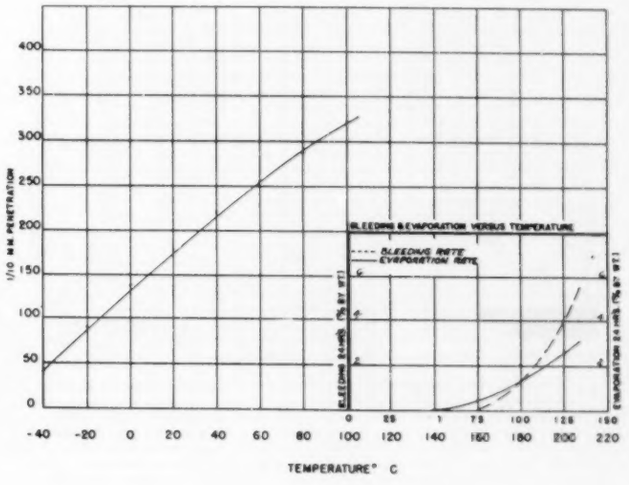
VISCOSITY INDEX 45

SPECIFIC GRAVITY AT 60°F. 924

DROPPING POINT °F. 437

TYPE OF OIL Petroleum Convention

CONSISTENCY VS. TEMPERATURE



GREASE TEST SUMMARY

CODE G-D

TRUE DESIGNATION :—

MANUFACTURERS NAME & LOCATION :—

SAMPLE RECEIVED FROM :

TEST DATA

TEST	HOURS OPERATED								TOTAL HRS.	TOTAL CYC.	R.P.M.	
	NO HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C				
1 (68)	20	200			200	200	244		964	42	10,000	
2	20	200			2				222	11	10,000	4
3	20	200			116				336	16	10,000	3
4	20	200			200	122			542	27	10,000	
5	20	200			60				280	4	10,000	3
6	20	200			200	200	378		1010	50	10,000	4
7	20	200			200	200	200	97	1017	54	10,000	
8	20	200			200	86			606	22	10,000	
9	20	200			200	152			372	18	10,000	
10 (37)	20	40							61	3	vapor	1
11 (66)	20	46							66	3	10,000	2
12												

TEST SUMMARY

TEMPERATURE CYCLE				
90°C	120°C	130°C	140°C	150°C
200 Hrs.	200	200	200	200

OPERATING TIME

MAX. AVG. MIN.

* FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

1 Tests #1, 2, 4, 6, 12 on G-30 not taken as valid tests these two not included on scale since this test not valid
2 Test #2 Keystone S-C not considered valid not included
3 Test #11 G-30 duplicates #7 not included
4 Test #1 Keystone S-C
5 Test #3 Keystone S-C
6 Test #9 Keystone S-C

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC AS % NA STEARATE 22

VISCOSITY OIL AT 100°F. 312

VISCOSITY OIL AT 212°F. 51

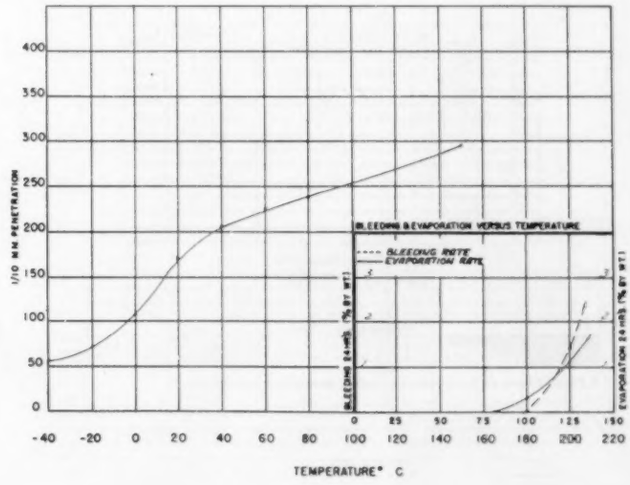
VISCOSITY INDEX 79

SPECIFIC GRAVITY AT 60°F. 898

DROPPING POINT °F. 373

TYPE OF OIL Petroleum Convention

CONSISTENCY VS. TEMPERATURE



GREASE TEST SUMMARY

CODE G-E

TRUE DESIGNATION :-

MANUFACTURERS NAME & LOCATION :-

SAMPLE RECEIVED FROM :-

TEST DATA

TEST	HOURS OPERATED 120 HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C	TOTAL HRS.	TOTAL CYC.	R.P.M.
1	20	200			22				242	16	10,000
2	20	41							61	3	10,000
3	20	167							187	7	10,000
4	20	184							204	10	10,000
5	20	191							211	10	10,000
6	20	200			8				228	12	10,000
7											
8											
9											
10											
11											
12											

TEST SUMMARY

* TEMPERATURE CYCLE				
90°C	120°C	130°C	140°C	150°C
200 Hrs.	200 Hrs.	200 Hrs.	200 Hrs.	200 Hrs.

OPERATING TIME

MAX. AVG. MIN.

* FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

1 Test not considered valid

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC AS % NA STEARATE 17 Na & Li

VISCOSITY OIL AT 100°F. 870

VISCOSITY OIL AT 212°F. 73

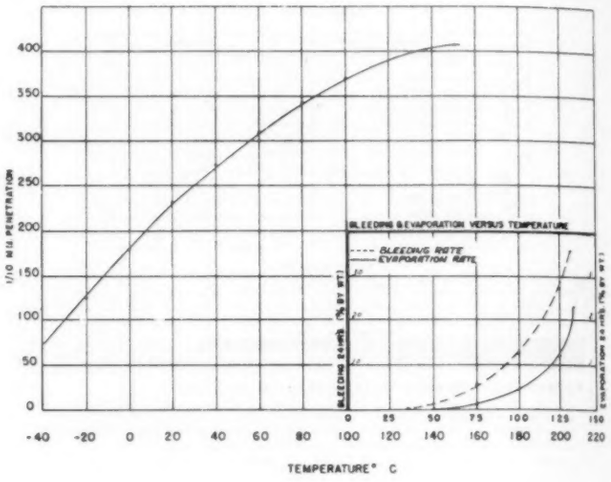
VISCOSITY INDEX 68

SPECIFIC GRAVITY AT 60°F. .917

DROPPING POINT °F 377

TYPE OF OIL Petroleum - Conventional

CONSISTENCY VS TEMPERATURE



GREASE TEST SUMMARY

CODE G-F

TRUE DESIGNATION :-

MANUFACTURERS NAME & LOCATION :-

SAMPLE RECEIVED FROM :-

TEST DATA

TEST	HOURS OPERATED 120 HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C	TOTAL HRS.	TOTAL CYC.	R.P.M.
1	20	132							152	7	10,000
2	20	151							171	8	10,000
3	20	200			73				293	14	10,000
4 (48)	20	188							208	10	10,000
5	20	172							192	9	10,000
6	20	200			8				228	11	10,000
7	20	149							169	8	10,000
8	20	200			20				240	12	10,000
9											
10											
11											
12											

TEST SUMMARY

* TEMPERATURE CYCLE				
90°C	120°C	130°C	140°C	150°C
200 Hrs.	200	200	200	200

OPERATING TIME

MAX. AVG. MIN.

* FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC AS % NA STEARATE 45 Na

VISCOSITY OIL AT 100°F. 554

VISCOSITY OIL AT 212°F 58

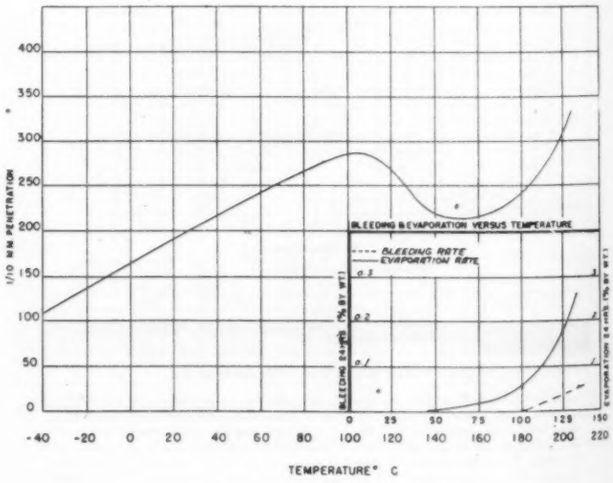
VISCOSITY INDEX 59

SPECIFIC GRAVITY AT 60°F. .916

DROPPING POINT °F 500+

TYPE OF OIL Petroleum Conventional

CONSISTENCY VS TEMPERATURE



GREASE TEST SUMMARY

CODE # G-G

TRUE DESIGNATION :—

MANUFACTURERS NAME & LOCATION :— Master Lubricants Co Philadelphia Pa

SAMPLE RECEIVED FROM :— Stock

TEST DATA

TEST	HOURS OPERATED								TOTAL HRS.	TOTAL CYC.	R.P.M.
	NO HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C			
1	20	200	200	50					470	23	10,000
2	20	112							140	8	10,000
3	20	200	200	37					457	22	10,000
4	20	200	200	160					580	27	10,000
5 (212)	20	200	174						394	19	10,000
6											
7											
8											
9											
10											
11											
12											

TEST SUMMARY

TEMPERATURE CYCLE				
90°C	100°C	110°C	120°C	130°C
200 Hrs	200	200	200	200

OPERATING TIME

[redacted] MAX. AVG. MIN.

% FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC. AS % NA. STEARATE 22.55 5.8 Li 12 mg % Na

VISCOSITY OIL AT 100°F. 274

VISCOSITY OIL AT 212°F.

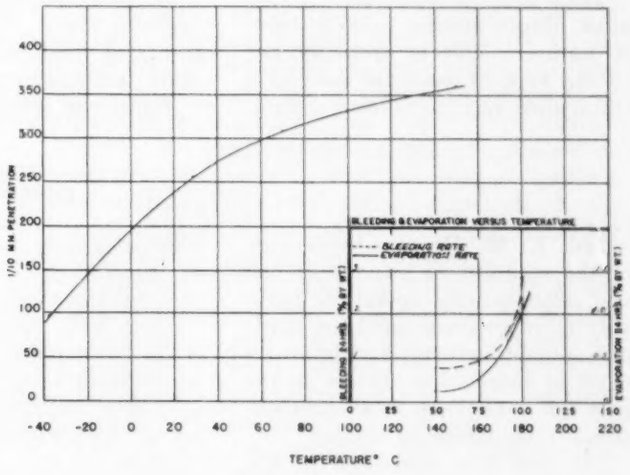
VISCOSITY INDEX

SPECIFIC GRAVITY AT 60°F. 0.925

DROPPING POINT °F 347

TYPE OF OIL Petroleum Conventional

CONSISTENCY VS. TEMPERATURE



GREASE TEST SUMMARY

CODE # G-H

TRUE DESIGNATION :— Lubrika M-21

MANUFACTURERS NAME & LOCATION :— Master Lubricants Co Philadelphia Pa

SAMPLE RECEIVED FROM :— Ordered by designation from manufacturer

TEST DATA

TEST	HOURS OPERATED								TOTAL HRS.	TOTAL CYC.	R.P.M.
	NO HEAT	90°C	100°C	110°C	120°C	130°C	140°C	150°C			
1 (107)	20	44							64	3	10,000 1
2	20	51							71	3	10,000 1
3	20	200	200	47					467	24	10,000
4	20	200	200	116					536	27	10,000
5	20	200	200	116					536	27	10,000
6	20	200	200	200	19				639	32	10,000
7											
8											
9											
10											
11											
12											

TEST SUMMARY

TEMPERATURE CYCLE				
90°C	100°C	110°C	120°C	130°C
200 Hrs	200	200	200	200

OPERATING TIME

[redacted] MAX. AVG. MIN.

% FIRST 20 HRS. OF OPERATION NO HEAT IS APPLIED TO BEARINGS.

1.— Test not considered valid

PHYSICAL AND CHEMICAL PROPERTIES

SOAP CONTENT CALC. AS % NA. STEARATE

VISCOSITY OIL AT 100°F.

VISCOSITY OIL AT 212°F.

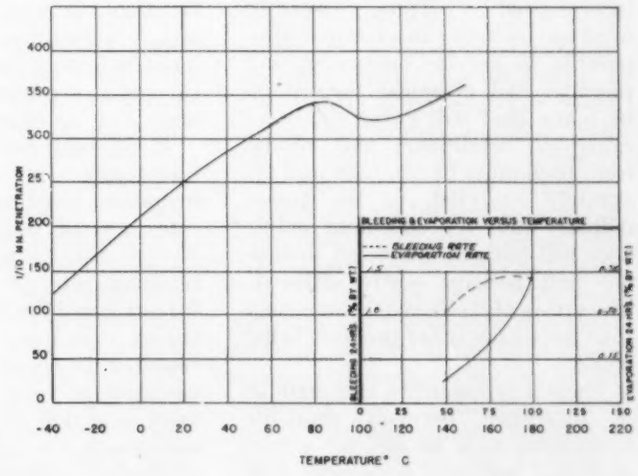
VISCOSITY INDEX

SPECIFIC GRAVITY AT 60°F.

DROPPING POINT °F

TYPE OF OIL Petroleum Conventional Sal. Oxidant inhibited

CONSISTENCY VS. TEMPERATURE



high temperatures indicate that G-H has a longer operating life than G-G. Tests conducted at 4000, 6000, and 8000 rpm. at lower temperatures bear out this indication. Since the only difference among these greases is the inclusion of an antioxidant inhibitor in G-H, it is logical to expect increased operating life by inhibiting a grease to the optimum degree.

Tests thus far made have shown most silicone greases to be abrasive in nature. This is probably due to the type of material used as a thickening agent. Silicone greases Nos. 1 and 2 are two greases only recently received which are not abrasive even though silicone oil is used. It is believed that lithium stearate has been used as the thickening agent. These greases are more promising than other silicone type greases for both low- and high-temperature operation. Two greases on which tests are being made are manufactured purportedly with synthetic oil of the petroleum type. These greases G-I and G-J hold some promise as a wide temperature-range grease.

From the information obtained, it may be concluded that functional testing is a satisfactory though time-consuming method for evaluating lubricating greases. Care must be exercised in operating the tests and interpreting the results, particularly in this type of test where actual apparatus is used. We may also conclude that where such wide spreads exist between maximum and minimum life of bearings, the accuracy of the summary will depend on the number of tests made.

DISCUSSION

MR. E. M. HIGGINS.[1]—Because of the stimulus of interest in ball and roller bearing operation, probably more progress has been made in the manufacturing and improvement of lubricating greases in the past ten years than in all previous grease manufacturing history.

The test data presented by Mr. Macphearson are of particular interest as they indicate the attempts being made to correlate both old and new physical and chemical phenomena with operating characteristics. Such comprehensive testing as outlined is very stimulating to those who are trying to make better lubricants. Such testing in the future will create a demand for even better lubricating greases and will to a great extent indicate desirable properties which should be incorporated. Tests, however, must be conducted in a manner comparable to service operation, and physical and chemical tests must be made that will cover the same range of conditions, and results from both must be carefully and accurately analyzed, or the grease industry and the consumer industries will both be subjected to serious and perhaps costly setbacks. The errors of hasty conclusions may thus jeopardize other progress being made.

There is necessarily a vast amount of difference between short-life equipment such as aircraft generators and industrial equipment with long-life expectation. This is true not only of problems dealing with electric motors and generators but is true for the entire field of ball and roller bearing applications.

It is well known that the A.S.T.M. is making progress toward establishing a standardized method of grease evaluation by functional tests. Such a project should include work on all sizes and types of ball and roller bearings operating under all ranges of service conditions.

In considering the correlation of physical and chemical properties, such as those presented with operating characteristics, it must be remembered that the size and type of bearing and the operating conditions largely determine the critical nature of each of these properties. For instance temperature-consistency values have little apparent effect upon grease life in small bearings operating at high speeds and temperatures. On the other hand, in large cylindrical and spherical roller bearings, grease consistency is of the utmost importance.

It has been pointed out that for high-temperature and high-speed operation, bleeding and evaporation rates are of primary importance. Evaporation rate and probably bleeding rate are very important for any condition of operation. The theory that some oil separation or bleeding to some extent is highly essential to long bearing life has been indicated by almost all functional tests which have been recently conducted. These tests have shown that greases with little or no bleeding and those which bleed excessively are not entirely satisfactory for many conditions of operation. They do, however, leave us in doubt as to the most desirable rate of bleeding.

If we assume that some bleeding is essential, then it follows that for maximum life a given quantity of grease should contain the greatest amount of oil possible consistent with the grease's ability to function in a housing with little or no detrimental churning and with a minimum amount of leakage.

The test results shown in the test summary sheets and the physical and chemical property sheets make it appear that oil viscosity in the grease has little effect on operating life at high temperatures. Further investigations may conceivably show us the desirable viscosity limits for any given condition of operation.

Further investigations may also show us that border line for grease lubrication where operating life with grease would be too short for industrial applications. Oil lubrication at this point might be indicated.

Mr. Macphearson has pointed out an interesting variable which he calls housing factor. This factor which is essentially a variable dependent on housing design has rarely been considered a necessary factor in the determination of lubrication life. If we consider that bleeding rate is an essential of long lubrication life, then it is important that both test equipment and actual apparatus should have housings that are designed so that the maximum advantages can be obtained

[1] Master Lubricants Co., Philadelphia, Pa.

from the oil released from the soaps.

A housing design which offers some movement assistance to the grease and at the same time limits grease and oil leakage is very desirable for long lubrication life under any type of operating conditions. The method practiced by some grease investigators of simply smearing the bearing with grease without benefit of proper housing and accessory grease pack is not, in the writer's opinion, a desirable method of testing grease.

It may also be pointed out that poor housing designs not only affect the lubrication life and the correct operation of the equipment but also jeopardize the chances of the maintenance man doing a satisfactory servicing job on the equipment.

Better lubricants will, to some extent, make up for the numerous violations of good judgment in the application of lubricants that have been noted in many instances. A progressive step in lubrication is being made when work such as that described by Mr. Macphearson leads to better lubricants, and the consumers using these lubricants employ a higher type of maintenance man in their application.

It has been a pleasure to be permitted to comment on Mr. Macphearson's paper and I feel that Mr. Macphearson and his associates are to be congratulated in bringing to our attention these new phases of grease testing.

MR. MARSHALL ANDERSON.[2]—The evaluation of greases by the method described in Mr. Macphearson's paper is thorough and convincing. It may properly be used to select the one best lubricant for a given type of apparatus when the operating conditions are known or can be reasonably approximated. It does not necessarily always follow that the same grease or greases will perform similarly in other apparatus or under different operating conditions.

Obviously, the results of any single test run of this kind are not reproducible, for no attempt is made to control several important variables to any closer degree than normal commercial tolerance limits. In this way slight inaccuracies in the bearings, their internal clearances and their mounting all contribute to the operating conditions of a particular test run. This, instead of being a disadvantage as it might first be considered, is believed to be an important advantage of this method, for the best lubricant is the one which does the best job when conditions are not ideal. In other words, lubrication requirements are likely to be vastly different in commercial applications than in nearly perfect laboratory test setups.

The nonreproducibility of results indicates that any conclusion must be based on statistical analysis of the results of a number of tests. It is questionable perhaps whether five test runs on each grease are sufficient for statistical purposes. However, by exercising judgment in the interpretation of results and by making additional runs when inconsistencies were too great, it is felt that gross inaccuracies have been avoided. Also, the same five aircraft generators were used for all tests, and each grease was tested in all generators.

One criticism the writer has of all high-temperature grease testers he has seen is that bearing temperature is held constant by artificial means regardless of how much heat is developed by the bearing or grease. Certainly in most practical applications the temperature is an incidental result of losses in the bearings added to ambient temperature conditions. A grease which keeps bearing temperature rise at a minimum is certainly to be preferred over one which produces considerable temperature rise. Furthermore, the grease which maintains a low heat contribution throughout its useful life is more desirable than one which gradually develops more and more heat as physical changes occur due to age. Would it not be more realistic to base all tests on standard ambient conditions and standard housing heat-dissipating constants?

Mr. Macphearson has found some correlation between bleeding and evaporation characteristics and lubricating life of greases. To those who hold to the theory that grease lubricates ball bearings by bleeding oil, it seems reasonable that such correlation should exist. However, there is doubt in the writer's mind that a 24-hr. bleeding test is conclusive, based on his observations of tests continued over a much longer period. The 24-hr. test may give an indication of expected behavior but not always a direct prediction. In general, bleeding rates have been observed to decrease with time, unless chemical changes in the grease cause it to release free oil more rapidly. Evaporation appears to proceed at a fairly constant rate at constant temperature. Agitation of the grease, as in a bearing, probably hastens both reactions.

A mathematical approach to the question of lubrication life as proposed by Mr. Macphearson is much to be desired. Whether the many variables, physical and chemical, involved in grease performance can be expressed with mathematical precision is extremely doubtful. Yet, in spite of this great doubt, the writer believes that such an approach can do much to clarify this complicated and often mysterious process. In so far as the subject yields to such analysis, the correct selection and application of lubricants ceases to be an art and becomes a science.

Thus, if the optimum rate of flow of oil into a ball bearing is known for some constant condition of operation and the efficiency of the housing in preventing leakage were known, it would theoretically be possible to predict the total life of a given charge of grease and to choose the grease whose bleeding rate (minus evaporation) most nearly approximates the needs of the application. This latter grease would presumably give the longest life.

It is at once obvious that this is an oversimplification of the case, and that other considerations must be factored in which might radically change the result. This should not discourage the investigator, however, for as each variable is brought under analytical control the nature of the problem becomes clearer.

[2] Motor Engineering Div., General Electric Co., River Works, West Lynn, Mass.

Peacetime Heating Oil Classifications

By M. A. Powers[1]

EDITOR'S NOTE:

An Outstanding Cooperative Research Project

The accompanying paper is essentially a description and news account of a very extensive research program and fundamentally is of importance to every producer and user of burner fuel oils. Mr. Powers, in his capacity as chairman of the technical committee directing the work, has not attempted to prepare a technical paper and consequently his discussion should be of interest to a great number of our members and BULLETIN readers.

When radical changes in the manufacture of fuel oils are made, the practical significance of such changes on the burning characteristics should be evaluated so refiners and burner manufacturers may fully appreciate any utilization difficulties which may arise. To solve this problem it was essential for the fuel oil producer and the burner manufacturer to get together, which is just what they did through Technical Committee E. Fifty-five thousand gallons of reference fuels were produced in line with the committee specification and this was shipped to some 34 laboratories who carried out the burning tests in accordance with the committee's desires. The recommendations and results unquestionably are of great interest to the industries concerned—and the work will have proved to be of immense value. While the research program was a very extensive one, it is significant to realize that the value of the fuel oil produced might run to an annual figure of $400,000,000. Adding to this the cost for domestic burning equipment, we have a tremendous dollar volume of products involved.

This research project is a splendid example of the type of work frequently carried out under A.S.T.M. auspices and which is a practical demonstration of the valuable know-how concentrated among the outstanding technical leaders serving on A.S.T.M. committees.

IN ORDER intelligently to evaluate the importance of the work assigned to Technical Committee E on Burner Fuel Oils of the Society Committee D-2 on Petroleum Products and Lubricants, it is well, first of all, to understand something of the history of the domestic oil burner and the fuel required for its satisfactory operation. In the interest of simplification, this discussion is limited to oil burners for home heating purposes.

BACKGROUND AND HISTORY

The domestic oil burner came into being shortly after World War I, and its acceptance was accelerated in the early 1920's by the effects of the serious coal strikes of that period. Table I traces the rapid growth of automatic heat with oil by noting the number of burners sold, a conservative estimate of the total in operation, the extent of manufacture as reflected by the number of burner manufacturers whose products were listed by Underwriters' Laboratories, and the approximate cost of the installation to the home owner. Steady lowering of the cost of the equipment, as well as its convenience, explains why oil heat has found rapidly growing acceptance in smaller homes.

Assuming an average yearly requirement of 1400 gallons for each burner in operation, there is indicated an annual requirement of about 3½ billion gallons of oil for power-operated burners. The Oil-Heat Institute estimates an annual sale of 500,000 units for the first five postwar years. This will call for an additional 700 million gallons each year to care for new installations alone. (See Table II).

It is obvious that the public is completely cognizant of the benefits of automatic heat and expects these benefits of comfort, convenience, and cleanliness in new homes, regardless of how little such homes may cost. This trend is especially emphasized by one important division of oil heating, the full extent of which is frequently not realized by oil refiners and manufacturers of conventional power type burners. Reference is to the vaporizing pot type burner, which during 1946 alone will find its place in very large numbers of new space heaters, furnaces, and the like.

These burners are low in original cost and although limited in burning capacity, are well adapted to small homes where a certain amount of operating care is expected. A conservative estimate places over 2½ million of them already in operation. With an average yearly requirement of 650 gal. of light distillate oil, a grand total of over 1½ billion gallons is required for pot type burners alone. To this

TABLE I.—POWER-OPERATED DOMESTIC OIL BURNERS.

Year	Annual Sales	Total in Operation	Number of Manufacturers Listed by Underwriters	Average Retail Price per Installation
1920..	5 000	10 000	2	$1050
1925..	45 000	175 000	30	$ 980
1930..	120 000	670 000	185	$ 625
1935..	150 000	1 152 000	230	$ 320
1936..	220 000	1 340,000		
1937..	211 000	1 530 000		
1938..	179 000	1 668 000		
1939..	236 000	1 862 000		
1940..	302 000	2 135 000	280	$ 275
1941..	333 000	2 402 000		
1942..	99 000	2 386 000		
1943..	33 000	2 384 000		
1944..	50 000	2 413 000		
1945..	111 000 Estimated	2 450 000 Estimated	182	

VAPORIZING POT TYPE BURNERS

Estimated total operating in 1945	2 500 000 units
Estimated annual production each of next five years	750 000 to 1 000 000 units

TABLE II.—DOMESTIC HEATING OIL REQUIREMENTS.

Existing power burners averaging 1400 gal. per yr..	3 430 000 000 gal.
Existing pot type burners averaging 650 gal. per yr...	1 625 000 000 gal.
Total	5 055 000 000 gal.
Estimated Yearly Increase for New Installations Only:	
500,000 power burners (estimate by Oil-Heat Institute)	700 000 000 gal.
750 000 pot burners	487 500 000 gal.
Additional yearly requirements	1 187 500 000 gal.

[1] Chairman, Technical Committee E on Burner Fuel Oils of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants; and Chief Engineer, Timken Silent Automatic Div., The Timken Detroit Axle Co., Detroit, Mich.

must be added an estimated increase of at least 750 thousand units and 480 million gallons of oil each year for the next five years.

Summarizing, we have a grand total of 5 billion gallons of oil not heavier than grade 3 of the commercial standards for existing installations. Assuming a cost of 8 cents per gallon, a volume of business for the oil industry of at least $400,000,000 is indicated for 1946. Thus, in respect to continuing revenue, the oil industry is in an attractive position as it continues to sell fuel year after year to each installation which the burner manufacturer can hope to sell but once. On the other hand, the oil man is dependent upon the burner manufacturer for a product which will burn his oil satisfactorily and reliably over the years. The interdependence of the two is thus quite obvious and it is their mutual desire to give the home owner all of the comforts of automatic heat.

Fuel Oil Specifications

In the early days of home oil heating no definite specification existed for the fuel. It was largely a matter of local concern for the supplier to deliver a product which would give reasonable satisfaction in the particular burners installed in his territory. Actual needs varied and the burner manufacturer was quick to claim any practical advantage for cheaper fuel which his burner could handle. The oil supplier also wished to give his customer every advantage of an oil best suited to his particular burner. Thus, many different grades of oil were advertised, often to the confusion of the oil man and the burner dealer, not to mention the customer. Identification was frequently by gravity, color, or by some name usually associated with usage or refinery nomenclature. No uniformity existed in different sections of the country, and frequently there was none in the same locality.

With the increase of oil heating, there was a definite need for some uniform method of identification, with specifications for each grade. This was recognized very early at the Underwriters' Laboratories in Chicago, where all manner of oil burners are submitted for test to determine conformity with the various safety requirements. Obviously, the oil used in such tests must conform to known and uniform standards; otherwise it would be impossible to maintain any semblance of uniformity in tests. Furthermore, there was no assurance that proper oil could be provided for burners which were approved, unless suitable grading was decided upon and widely accepted in the field so that the user could purchase the correct grade locally.

To meet the urgent need for clear and definite oil grade specifications, efforts were made by the oil producer and burner manufacturer as represented by their trade associations, by Underwriters' Laboratories, and by the National Bureau of Standards.

On January 9, 1929, a conference of representative refiners, distributors, and consumers of fuel oil, manufacturers of oil burners, and general interests approved a recommended standard for domestic and industrial fuel oils, which was accepted in writing by the trade and published as Commercial Standard CS12-29. In 1933, 1934, and 1938, revisions were adopted. In 1939, revisions were drafted by Technical Committee E of A.S.T.M. Committee D-2 and circulated for study. The revised standard was promulgated by the U. S. Department of Commerce, through the National Bureau of Standards, as CS12-40, and it is the present standard. The corresponding A.S.T.M. specifications D 396-39T, also give the detailed requirements for the five grades of fuel oils covered.

Need for Study and Research

Advances made to meet the high-octane gasoline demands of the war years have resulted in major changes in the refining processes and serious questions have been raised on the ability of existing and projected postwar oil burning equipment to use the new types of fuel oils efficiently and economically. Before the war there was an increasing percentage of domestic fuel oils produced by thermal cracking methods. Generally speaking, such oils, while having most of the characteristics common to the straight run distillates, were more difficult to burn effectively in the various types of oil burners without smoke and with satisfactory combustion efficiency. This situation has generally been attributed to the molecular structure of such cracked products which contain more carbon and less hydrogen. The increased ratio of slow-burning carbon to fast-burning hydrogen slows combustion. With the customary air adjustment, there is a tendency for smoking and increasing the air reduces the combustion efficiency. However, progress was being made in burning these fuels efficiently. Although some burners were reported able to burn 100 per cent thermally cracked oils with entire satisfaction, such operation was unusual.

Then came the war, and with it a greatly accelerated introduction of catalytic refining methods for high-octane gasoline. More than two thirds of the present catalytic refining capacity was built during the war. With the increased flexibility of this process and the improved quality of output from the point of view of gasoline-minded production, there is every indication that refineries equipped with catalytic stills intend to continue to use them to the utmost. Consequently it is reasonable to conclude that an appreciable percentage of catalytically cracked products may find their way into postwar heating oils.

With this premonition of future trends, the oil industry with the assistance of the National Bureau of Standards prepared a "Draft of Assumptions and Basic Facts Concerning Production and Use of Fuel Oils" which under date of May 18, 1944, was presented at a joint conference of oil burner manufacturers and refiners at Chicago. This conference referred the various technical problems to Technical Committee E on Burner Fuel Oils, and shortly thereafter the Advisory Committee of Committee D-2 confirmed the assignment. The committee convened in New York, N.Y., on July 27, 1944, at which time all angles were discussed and a definite program of study outlined.

An Urgent Problem

The most urgent problem was to

determine the burning characteristics of the new catalytic oils since they were already being supplied mixed with straight-run fuels and troubles were being encountered. Pooling of fuels for domestic use, particularly in the East, made it difficult to establish clearly the cause for the troubles.

Most burner manufacturers were entirely unfamiliar with catalytic oils and had, in fact, only started to learn something about thermally cracked fuels in the operation of their burners. Generally speaking, the results had not been very satisfactory and the catalytic fractions seemed to be acting in somewhat the same manner. But no one had many facts. Furthermore, the problem was made no easier by the involved analysis necessary to identify oil samples from the field. Practically speaking, no oil distributors could make the identification, and usually the answer could be obtained only by sending samples to the refinery laboratories. Even with a complete analysis at hand, only a few oil technologists would venture to predict how the oils would burn in a particular burner and why.

The problems confronting Technical Committee E, then, were forecasting the kinds of oil which would most likely be availale for general use after the war, formulating specifications for sample lots in various grades, and arranging for adequate quantities to be made available for widespread practical test. This formidable task was assigned to Section I on Reference Fuels. It was important that this section formulate fuels which the refiner could produce effectively, which existing and postwar burners could burn reliably, and still be satisfactory and economical fuel for the customer.

Two grades were selected. The No. 1 Reference Oil was about 80 per cent straight run, the remainder catalytic, and represented what might be expected as a light fuel for pot type vaporizing burners. The No. 2 Reference Fuel was 100 per cent catalytically refined and represented about the worst that the burner people might be expected to burn postwar in the various types of power-operated domestic burners.

The object was for Section II to make tests on these two fuels and blends of the same, in order to determine just what composition would adequately serve the burners. This composition and tests of the same would then serve as a guide in formulating a classification for products which the refiners could economically produce.

After deciding upon the analyses, Section I proceeded to have quantities of oils made to these exact specifications for test burning by the various burner manufacturers and oil laboratories. Approximately 18,000 gal. of No. 1 Reference Fuel and 37,000 gal. of No. 2 Reference Fuel were made, distributed, and burned in obtaining the facts upon which Technical Committee E will shortly base its recommendations.

The actual tests came under the supervision of Section II, Section I having completed the main portion of its assignment upon delivery of the special reference oils. Section II on Burner Tests Using Reference Fuels functioned in close cooperation with Oil-Heat Institute—the chairman of Section II also being chairman of the Institute's Engineering Committee. There was good reason for this. As the membership of Section I was predominately oil technologists, so that of Section II was mostly practical combustion engineers. It became their duty to formulate a comprehensive test procedure and determine exactly how the new oils burned under a wide variety of operating conditions.

The routine procedure of arranging for all burner manufacturers to test their own burners in their own laboratories, even after the detailed tests had been prescribed, required much time and effort. It necessitated among other things, sending out test forms and instructions, arranging oil deliveries, following through with assistance during the tests, and then collecting and tabulating the results. All test data were confidential and the Technical Secretary of Oil-Heat Institute was the only one authorized to receive the information. It was his duty to bring all of this information together in suitable form for the use of Section II, each individual laboratory now being identified by a code number. Thus a great volume of data was condensed, correlated, and presented to Section II in October, 1945.

A total of 34 laboratories participated in the program and with few exceptions completed the prescribed test procedure. There were four general classes of burners: high-pressure, low-pressure, wall-flame rotary, and vaporizing pot type. These were installed in various kinds of heating equipment: space heaters, furnace-burner units, boiler-burner units, floor furnaces, stoves, and conversion units.

Results of Tests

The results of Section II's deliberations in summary form with conclusions as to the practicability of burning the Reference Oils in various well-known types of burners follow:

Space Heaters with Vaporizing Pot Type Burners:

Of the eight laboratories which conducted tests on space heaters equipped with vaporizing pot type burners, seven disapproved, without qualification, the reference oils in all blends. The eighth neither approved nor disapproved them, but reported only small deposits of carbon in the pot and on the heating surfaces at the conclusion of a 250-hr. cycling test.

Furnace, Floor-Furnace, and Conversion Vaporizing Pot Type Burners:

In this group there were six laboratories: four conducted tests of vaporizing pot type burners in furnace-burner combinations, one conducted a test in a floor furnace, one conducted an additional test of a conversion burner, and another tested a conversion burner alone. Of the group which conducted tests in furnace-burner combinations, one estimated that his unit would require servicing about every 60 days when using catalytic oils, another said the carbon deposits were heavy which would amount to about the same thing; the third said that frequent removal of carbon would be necessary, and the fourth said the results were unsatisfactory due to excessive carbon and soot. This

group was thus unanimous in believing that catalytic oils would result in excessive service maintenance due to carbon and soot deposits.

One laboratory which conducted one test on a floor furnace and a second test on a conversion burner states that the results obtained were satisfactory with the No. 2 Reference Fuel. Another laboratory which conducted a test of a conversion vaporizing pot type burner also obtained satisfactory results.

High-Pressure, Low-Pressure, and Wall-Flame Burners:

There were eleven laboratories in this group of which eight conducted tests on high-pressure burners, four conducted tests on wall-flame burners, and one conducted tests on a low-pressure burner. In the high-pressure group comments were made that smoking prevailed with the catalytic oils for the first 5 to 7 min. after starting. This will be a disadvantage with burners required to operate on frequent short cycles. In two cases a laboratory redesigned the burner firing head in order to obtain results considered satisfactory. Reports that carbon collected on the helix of the stack switch were also made. In one instance the laboratory commented that at a firing rate of $\frac{1}{2}$ gal. per hour, 10 per cent CO_2 and smoke-free combustion cannot be maintained.

Of the four laboratories which conducted tests on wall-flame burners, one reported complete satisfaction with the catalytic oils, one stated that the burner flame rim had to be modified for satisfactory results to be obtained, a third said that a considerable quantity of carbon collected in the ignition groove but did not impair operating characteristics, and the fourth reported satisfactory results during the 250-hr. cycling test but considered the ignition test to be unsatisfactory because of slow igniting.

The single laboratory which conducted a cycling test on a low-pressure burner reported completely satisfactory results but commented that it might prove advisable to operate at 8 or 9 per cent CO_2 instead of 10 per cent or above.

Conclusions of Committee

The conclusions of Section II on the suitability of A.S.T.M. Reference Fuel Oils Nos. 1 and 2 for vaporizing pot type burners and for high-pressure, low-pressure, and wall-flame burners are as follows:

The majority of the laboratories reported that neither No. 1 nor No. 2 A.S.T.M. Reference Fuel Oils, nor blends thereof, is satisfactory for vaporizing pot type oil burning equipment. This is due principally to the following conditions:

1. Excessive carbonization at the oil inlet to the pot.
2. Carbon and soot deposits in the pot and on the secondary surfaces.
3. A reduction in the maximum Btu. output capacity of the burner.

They also reported that under continuous operating conditions these fuels can be burned as required by the Commercial Standard with respect to draft, CO_2, and smoke, with a reduction in output varying from 5 to 25 per cent. A reduction of the oil input rate improves the soot and carbonization conditions, but the deposits should be regarded as cumulative, or progressively increasing, with increased hours of operation.

The majority of the laboratories reported that Nos. 1 and 2 A.S.T.M. Reference Fuel Oils and blends thereof can be burned satisfactorily in high-pressure, low-pressure, and wall-flame rotary burners with no modifications or with minor modifications of burner or combustion-chamber design, and with increased air flow to compensate for the higher heat content of the fuel. Existing installations of rotary wall-flame burners may require some changes in hearth design to burn No. 2 oil. One laboratory questioned the proper operation of high-pressure burners on short operating cycles. A blend of 70 per cent No. 2 and 30 per cent No. 1 seemed to overcome this difficulty without the need of burner modification except in one instance where smoking conditions were reported even with No. 1 oil on a high-pressure burner operating on short cycles in a warm air furnace. In this case the opinion was expressed by the testing laboratory that carbon would be built up on the heat exchanger and on the helix of the stack switch.

All data are now before Section III on Fuel Oil Specifications. In addition, this group will also receive results from Section IV on Stability, Sedimentation, and Corrosion, which has been active concurrently on the investigation of other important properties of fuel oils. Section III is now evaluating the information presented to it, with the responsibility of recommending such changes in fuel specifications as they may feel desirable. Such recommendations in turn will then be presented to Technical Committee E as a whole for consideration before final action is taken. It is difficult to estimate when the job will be completed, but continuation of the steady progress to date may be expected.

It is gratifying to the author, as it must be to each individual who has had a part, to realize that the extensive program undertaken by Technical Committee E is now well advanced. The invaluable data are becoming available at a most opportune time in the postwar development of the fuel oil and oil burner industries. With what foresight and wisdom each industry uses these facts to advance its own position in the respect and good will of its customers remains to be seen. With the public vitally interested in automatic heat, no one will deny that great opportunities now await the oil heating industry.

The Evaluation of Surface-Active Agents

By Jay C. Harris[1]

Materials which reduce surface tension, foam, and exert detergent properties have been available for centuries, but their deficiencies became apparent only as general knowledge advanced to the state of criticism of existing materials. The desire and ability to change this situation ensued, and improvement in these early materials resulted in search for methods to demonstrate possible superiority of newly developed compositions. As a consequence, the literature contains hundreds of papers covering the variety of test methods and measurements which were made. Under the circumstances, it is not unusual that recognized methods from the field of physicochemical research should be applied, but the wide possible application of these compositions also necessitated the utilization of methods from other, less closely affiliated fields. Improvements both in the agents and in evaluation methods of necessity were gradual, but development of the really effective agents about fifteen years ago resulted in more intensive study of the methods for evaluation. As compounds of improved characteristics appeared, reproducible and significant evaluation tests became more necessary in order to differentiate between their more closely approaching degrees of activity.

Seldom is the conscientious worker entirely satisfied with abstract data, since only too infrequently has the connection between such data and specific usage been established. This need for methods which would duplicate practical tests led first to the evaluation of specific properties of the agents such as lather, surface and interfacial tension, pH value, solubility, specific conductance, etc. It immediately became apparent when this information had been developed, that the experimental data seldom correspond exactly to practical results. As often occurs, measurements of individual properties were then thrown into some disrepute, and many workers felt that no benefit could be derived from them, with the result that the opposite extreme of evaluation only by actual trial was adopted. It is possible to utilize the best of both views and, by combination of physicochemical knowledge of properties with practical experience, develop test equipment and methods suited to close control of all variables which will produce data convertible to actual operation. The final criterion of applicability will be trial under actual working conditions. Therefore, actual operating conditions should be approached in the laboratory as closely as possible, so that the specific agent will then be evaluated under optimum application conditions. As a matter of fact, for many purposes a number of agents may perform suitably, but some one application may be so specific that very few agents can be applied. Consequently, a knowledge of basic properties may minimize the evaluation work involved.

Evaluation

Reduced to fundamentals, evaluation of a surface-active agent should follow these lines:

1. Determination of properties.
2. Evaluation under simulated practical conditions.
3. Test in actual operation.

Test work under actual use conditions may best be carried out by responsible plant personnel assisted by one familiar with the chemical involved, but the first two evaluation steps demand a scheme for the measurement of individual properties, followed by evaluation with methods which may be correlated with practical values. A series of such test methods, which have proved their value over a period of years are later described, and their practical application is indicated.[2]

As a means for demonstrating comparative values of the test methods, a number of available surface-active agents comprising several radically differing chemical compositions are shown.

Surface-Active Agents:

Examples of several classes of surface-active agents are shown in Table I: Those of an alkyl-aryl type are the Areskap, Aresket, and Aresklene series and the Santomerse D and Santomerse No. 3 series. The sulfonated aryl carboxy estertype is exemplified by dihexyl sulfophthalate and Santomerse B; Santomerse TIB is an alkenyl carboxylate, while Santomerse DT is an example of *N*-alkylated alkylene polyamine. It is obvious that a thorough-going prediction of possible utility of these several agents or their homologs would prove extremely difficult, if not impossible, and that measurement of their properties would prove a necessity. Even in a homologous series represented by Santomerse D or No. 3, many potentially suitable materials may be developed, dependent upon the properties required: Water solubility is obtained with Santomerse D for example, while improved detersive action results when Santomerse No. 3 is used. It is presumable that a material with an alkyl side-chain length greater than 12 would exhibit lowered water solubility but improved solubility in nonpolar solvents. Even presence of a hydroxyl group as with Areskap will change the properties of the composition as compared with Aresket. The considerable effect induced by relatively small compositional variation, therefore, requires evaluation methods of adequate sensitivity.

With so many available agents the process of recommendation becomes more involved in some respects but perhaps simplified in others. Several agents may appear to be suitable for a given purpose but almost without exception some one product will prove more suitable than another. To provide suitable recommendation it may be necessary to evaluate the materials under conditions as nearly comparable with final use as it is possible to translate conditions to the laboratory.

Evaluation Tests:

The utility of the several tests which are described will become more apparent by comparison of the several agents. The evaluation tests described are:

1. Acid stability,
2. Alkali stability,
3. Caustic soda solubility,

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

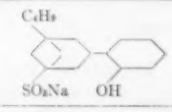
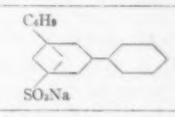
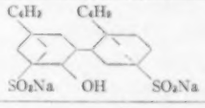
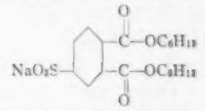
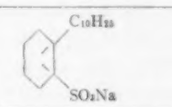
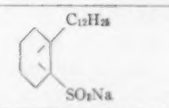
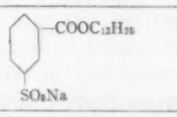
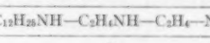
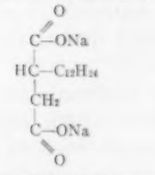
[1] Central Research Dept., Monsanto Chemical Co., Dayton, Ohio.

[2] These methods will be included in the second portion of this paper to appear in August ASTM BULLETIN.

4. Metallic ion stability,
5. Surface and interfacial tension values and spreading coefficient,
6. Lime soap dispersion,
7A. Draves-Clarkson wetting test,
7B. Canvas disk wetting test,
8. Lather value,
9. Organic solvent solubility, and
10. Detergent test.

Each method will be described separately in detail, but the application of the test results to the several surface-active agents shown in Table I will reveal their possible applications.

TABLE I.—SURFACE-ACTIVE AGENTS.

Agent	Commercial Grades			Structural Chemical Formula
	Trade Name	Per Cent Active	Type Product	
Areskap	Areskap 100	99+	Fine powder	
	Areskap 50	50	Paste	
Aresket	Aresket 300	99+	Fine powder	
	Aresket 240	40	Paste	
Aresklene	Aresklene 400	99+	Fine powder	
	Aresklene 375	75	Paste	
Dihexylsulfophthalate	.....	99+	Flake	
Santomerse	Santomerse D	99+	Fine powder	
	Santomerse S	30	Solution	
	Santomerse No. 3	99+	Fine powder	
	Santomerse No. 3 Paste	75	Paste	
	Santomerse No. 1	40	Flake	
	Santomerse No. 55	55	Flake	
	Santomerse B	99+	Flake	
	Santomerse DT	99+	Liquid	
	Santomerse TIB	99+	Powder	

NOTE.—Covered by following patents: U. S. 2,161,173 and 4, U. S. 2,298,651, U. S. 2,283,214, U. S. 1,921,546 U. S. 1,994,927, U. S. 2,135,978, U. S. 2,218,472, U. S. 2,267,205, U. S. 2,355,592, and U. S. 2,359,291.

ACID STABILITY

A surface-active agent chemically unaffected by acid has many uses. Soap is not useful under these conditions since it is decomposed, forming inactive, and many times obnoxious, oily or waxy fatty acids. Historically, the first improvement in agents for use in acid media was Turkey red oil, followed by highly sulfonated oils, and, finally, by the perhaps chemically more complicated agents, useful for a wider variety of purposes. Perhaps the textile industry was the first to utilize acid-stable compositions, but literally hundreds of uses have since developed. In the textile industry, the acid-stable agents are used among other purposes for acid-dyeing operations and in carbonizing baths. The metal trades utilize them in pickling and electroplating baths, and they may even be used in the acidization of oil wells.

Chemical stability may vary markedly among the available agents. Esters may be stable to slight acid concentrations for some time, but increase in acid concentration, temperature, or time of exposure may induce decomposition. Sulfonic acid types of agents generally are quite stable to acids, but sulfonic acid separation may be mistaken for decomposition.

One possible method for evaluating these agents is to add a known excess of acid to a given solution of the agent, boil under reflux, then back titrate, thus quantitatively measuring any change. This method, while quantitative, does not provide acid concentrations of the degree many times encountered in industry. Consequently the qualitative method later described has given adequate results, as shown in Table II.

Reference to Table II will indicate that Santomerse B, DT, and TIB are adversely affected by acid. Reference to Table I will show that Santomerse B is an ester, Santomerse DT an alkylene amine, and Santomerse TIB a disodium salt, so that their general instability might have been predicted, but their relative degree of stability would become apparent only upon actual trial. The other agents may therefore be used in acid media of considerable strength, but a further elimination would be required by evaluation under conditions approaching actual use as closely as possible. Combinations of tests such as acid stability, surface-tension measurements in acid media, and stability to metallic ions under acid conditions may prove adequate means for comparison of several otherwise identical materials.

TABLE II.—ACID STABILITY.

	Sample	Acid (H_2SO_4)			
		0.1 per cent	1.0 per cent	3.0 per cent	10.0 per cent
No. 1	Areskap 100	Stable	Stable	Stable	Stable
No. 2	Aresket 300	Stable	Stable	Stable	Stable
No. 3	Aresklene 400	Stable	Stable	Stable	Stable
No. 4	Dihexyl sulfophthalate	Stable	Stable	Stable	Stable
No. 5	Santomerse D	Stable	Stable	Stable	Stable
No. 6	Santomerse No. 3	Stable	Stable	Stable	Stable
No. 7	Santomerse B	Stable	Stable	Partial decomposition	Decomposed
No. 8	Santomerse DT	Stable	Stable	Decomposed	Decomposed
No. 9	Santomerse TIB	Stable	Decomposed	Decomposed	Decomposed

In many cases stability to acid may be required of a product which at some period of operation may be used in strongly alkaline solutions, and a test for stability to, or solubility in, alkali is indicated.

Alkali Stability and Solubility in Caustic Soda Solutions

Although soap is chemically stable to alkali, it may be salted out and loses its effectiveness whenever a sufficiently high caustic alkali concentration is reached. Consequently, there is a definite place for an alkali-soluble surface-active agent. Perhaps the outstanding use for an agent of this type is in mercerization, but surface-active agents are also used in the manufacture of viscose yarn. There are many other processes where lower alkalinity values are used in which fully soluble, active agents may be effective. It is obvious, however, that such agents must not be subject to decomposition, so that a suitable test may serve to screen out those agents most likely to successful application under the foregoing conditions of usage.

A second test of a more quantitative nature is used to determine the approximate solubility of the wetting agent in sodium hydroxide solutions, while saponification determinations may be made if the materials are of saponifiable nature and such quantitative data may prove necessary.

Few materials are fully soluble in 25 per cent caustic soda solutions, but in many cases such an agent is most desirable, so that an adequate screening test or tests may simplify practical testing materially.

TABLE III.—ALKALI STABILITY.
25.0 per cent NaOH.

	Sample	Salting-Out Effect	Chemical Stability
No. 1	Areskap 100	Partially salted out	Stable
No. 2	Aresket 300	Salted out	Stable
No. 3	Aresklene 400	Salted out	Stable
No. 4	Dihexyl sulfophthalate	Salted out	Stable
No. 5	Santomerse D	Salted out	Stable
No. 6	Santomerse No. 3	Salted out	Stable
No. 7	Santomerse B	Salted out	Stable
No. 8	Santomerse DT	Salted out	Stable
No. 9	Santomerse TIB	Salted out	Stable

Reference to Table III indicates that only Areskap 100 is partially soluble at the 25 per cent caustic soda concentration observed, but that all the agents appear chemically stable to this strength alkali. Reference to Table IV shows that Areskap 100 is soluble to the extent of 0.8 per cent in 21.6 per cent NaOH solution, confirming the indication of solubility given in Table III. The only other agents appreciably soluble in caustic soda are Santomerse TIB, (the sodium salt of a dibasic acid) and Santomerse D. Comparison of Santomerse D with No. 3 shows that the shorter alkyl chain of the former alkyl benzene sulfonate materially affects solubility, illustrating the possibilities of this homologous series. The low surface tension of the more dilute solutions of surface-active agent in dilute alkali are to be expected, but what actually is desired is surface tension lowering even in concentrated alkali, as shown by Areskap 100. However, lowered effectiveness of even this compound may be expected at caustic soda concentrations in excess of 21.6 per cent, or Areskap concentrations greater than 0.8 per cent at 21.6 per cent NaOH solution.

Acid and alkali stability and solubility are essential bases for the evaluation of wetting agents and detergents, but in many cases metallic ions of many kinds may also be present in solution.

TABLE IV.—CAUSTIC SODA SOLUBILITY.
Temperature 25 ± 3 C.
Maximum concentrations of caustic soda and wetting agent yielding clear solutions.

	Sample	NaOH, per cent	Agent, per cent	Surface Tension, dynes per cm. at 25 C.
No. 1	Areskap 100	21.6	0.80	35.3
No. 2	Aresket 300	<2.7	<0.10	32.8
No. 3	Aresklene 400	<2.7	<0.10	31.0
No. 4	Dihexyl sulfophthalate	<2.7	<0.10	40.3
No. 5	Santomerse D	4.2	0.15	31.4
No. 6	Santomerse No. 3	<2.7	<0.1	31.4
No. 7	Santomerse B	<2.7	<0.1	32.4
No. 8	Santomerse DT	<2.7	<0.1	35.1
No. 9	Santomerse TIB	7.8	0.29	33.8

Stability Toward Metallic Ions

Water solubility of the metallic salts of surface-active agents will greatly influence their ultimate application. First, these agents must be stable to the calcium and magnesium ions of hard water, since one of the factors unfavorable to soap is its ready formation of insoluble, sticky lime and magnesia soaps. In textile processing many operations require the use of acids, as for example, in dyeing, and metal from equipment may be dissolved, so that in this case the agent must not only be a good wetting agent but must be chemically stable both to acid and metallic salts incidentally formed. In carbonizing wool a wetting agent may find considerable usage, but must be stable to acid or to a combination of acid and aluminum salts. For scouring pulled wool, a detergent is required which is stable to lime salts. Other agents may be useful in metal salt solutions as in electroplating, pickling or soldering fluxes. Although the foregoing is but a partial list of uses where metallic salts are encountered, it should be evident that knowledge of solubility of the metallic salts of the surface-active agent should be available.

There are two general methods for obtaining these solubility data: One is to prepare the salts by metathesis or other process and determine their solubility; the other is to add the metallic ion in question to a solution of the agent and determine the point at which a given maximum degree of turbidity is obtained, where lathering ceases, or both. There are advantages to both methods. The preparation of the pure compound permits accurate measurement of values, but experience with metallic soaps, for example, has shown that the solubility characteristics are entirely different after drying than they are in solution or dispersion, prior to drying. Furthermore, attempted preparation of a salt will present an entirely different problem from one in which the metallic ion represents a small portion of the system. Casual contamination in many cases will give vastly different results from an attempt to measure the solubility of the salt in water, since the pH value of the solution will have profound effect upon degree of solubility. The method was chosen for evaluation purposes and in spite of its apparent inaccuracy, since good reproducibility and excellent application results have been obtained with it.

The specific metallic ions were chosen for this test for the following reasons:

1. Calcium and magnesium because they are responsible for water hardness.
2. Copper and nickel because of possible contamination from processing equipment.
3. Aluminum and iron salts because they readily form insoluble salts and any agent stable to them should prove useful for many purposes.
4. Barium was chosen because sulfates and even sulfonates are precipitated or become turbid in its presence.
5. Heavy metal salts because they are represented by lead contamination.
6. Zinc salts since they are somewhat amphoteric in nature and are present in certain processing baths.
7. Other salts or varying concentra-

TABLE V.—STABILITY TOWARD METALLIC IONS.

See Method 4, p. 17.

	Sample	Ca	Mg	Cu	Al	Ba	Fe	Pb	Zn	Ni
No. 1	Areskap 100	100	100	88	8	20	17	33	100	100
No. 2	Aresket 300	14	100	100	6	9	7	21	100	100
No. 3	Aresklene 400	23	100	100	6	15	27	35	100	60
No. 4	Dihexyl sulfophthalate	40	100	100	8	20	16	40	100	100
No. 5	Santomerse D	17	100	70	6	14	15	34	100	100
No. 6	Santomerse No. 3	16	100	78	6	18	17	30	39	37
No. 7	Santomerse No. 1	31	100	100	9	22	29	20	100	100
No. 8	Santomerse 55	12	53	73	6	8	6	9	49	39
No. 9	Santomerse B	100	100	100	17	19	15	42	100	100
No. 10	Santomerse DT	100	100	100	46	100	24	100	100	100
No. 11	Santomerse TIB	5	100	10	7	7	6	13	7	12

tions at varying pH values may advantageously be evaluated, but their applications are more specific.

Reference to Table V will provide some very interesting illustrations of the application of the various tests thus far described. The most stable agent appears to be Santomerse DT, but it should be recalled that DT is stable only to alkali and to very mild acid concentrations, so that its greatest utility will be found in alkaline baths. Santomerse B appears to be next most stable and can be used in either mildly alkaline or acid media.

The relative insolubility of the higher alkyl benzene sulfonates is indicated by comparison between Santomerse D and No. 3. The effect of dilution and "building" with sodium sulfate is apparent by examination of the results with Santomerse Nos. 3, 1, and 55; sodium sulfate exerts an effect other than as a mere diluent.

The tests which have thus far been described measure only stability effects of the various agents and are no indication of surface activity, so that a variety of materials could pass the foregoing tests favorably without possessing any surface activity. A test or tests which will measure this most important function is therefore a necessity.

Surface and Interfacial Tension Values and Spreading Coefficient

Potential detergent and wetting action may be ascertained by measurement of surface and interfacial tension. In general, the greater the ability to reduce surface tension and to lower the interfacial tension between oil and water, for example, the more useful the composition may be for producing desired effects under actual conditions of usage. These measurements have a practical application since dilution effect and quality may thus be indicated. The activity of certain baths, as for example electroplating baths, in which a surface-active "anti-pitting" agent has been used, may be controlled by use of these methods.

Only a few possible uses for this measurement of surface and interfacial tensions have been indicated, but it is apparent that since these values may have considerable bearing upon subsequent usage, a suitable means for their evaluation should be available.

Surface-tension measurements generally refer to the liquid-air interface, while interfacial tensions refer to interfaces such as liquid-liquid or solid-liquid. Since these interfaces are so interrelated, it is difficult to discuss them separately, but an attempt will be made to do so as a means for simplification.

Surface Tension:

Nine methods for measurement are listed in the Critical Tables (1):[2]

1. Capillary height or pressure,
2. Drop weight,
3. Maximum bubble pressure,
4. Capillary waves,
5. Vibrating jet,
6. Drop height,
7. Drop-shape,
8. Maximum pressure in drops,
9. Method of Sentis (capillary tube, hanging drop and measurement of meniscus height in tube above drop), and
10. Ring method.

It will be noted that the ring method was not developed until 1927 (2).

Perhaps the most generally used method is that employing the du Nouy ring tensiometer, the reasons for which will be pointed out later.

Interfacial Tension:

Wetting of liquid by a liquid, or solid by a liquid may be estimated by several methods. The solid-liquid interface may be measured by several techniques which require estimation of the angle of contact (3):

1. Pressure of displacement.
2. Horizontal plate.
3. Vertical bar.
4. Deposited film.

[2] Boldface numbers in parentheses refer to the list of references appended to this paper.

Liquid-liquid interfaces may be determined by several methods:

1. Stalagmometer (4).
2. Drop weight (Millard) (5).
3. Ring.
4. Ripple (6).

The facility with which a solution may wet another surface, whether solid or liquid, may have considerable influence upon subsequent operations. Cleaning or dyeing a fiber, wetting a metal surface or foliage, and formation of emulsions all are dependent upon optimum interfacial tension properties. As a matter of fact, repellency toward, rather than attraction of a surface for water or oil, is an important feature of numerous commercial processes and products.

The lower the surface and interfacial tensions of a system, the better the chance of forming an emulsion or wetting a given surface. Cupples (7) has applied these data to foliage wetting by utilizing the measurement of surface tension against air and against mineral oil. The spreading coefficient (*SC*) of a system may be calculated as follows:

$$SC = \text{Surface Tension Oil} - (\text{Surface Tension Solution} + \text{Interfacial Tension})$$

The more positive the value obtained, the greater the spreading value of a system. Consequently, the possible utility of the wetting agent for insecticidal sprays may be predicted as an emulsifier for mineral or other oil, or as a means for wetting oiled solid surfaces.

In general, the du Nouy instrument may most satisfactorily be used for liquid-liquid systems. One instrument may furthermore be used for the determination of both surface and interfacial tensions. For control purposes, the dial reading after calibration may be adequate, but if highest accuracy is desired, ring corrections have been developed (2, 8). A correction curve for surface-tension measurements is shown in Fig. 1. An example of how such a correction curve may be used follows: A dial reading of 33.7 is corrected by reference to the figure, the correction factor being 0.883:

$$33.7 \times 0.883 = 29.8 \text{ dynes per cm. (corrected)}$$

The surface-tension values shown in Table VI are corrected.

TABLE VI.—MEASUREMENT OF SURFACE ACTIVITY, SURFACE TENSION, INTERFACIAL TENSION SPREADING COEFFICIENT.
Temperature 25 ± 1 C.

	Sample	Surface Tension, dynes per centimeter			Interfacial Tension, dynes per centimeter			Spreading Coefficient		
Concentration		1.0%	0.25%	0.0625%	1.0%	0.25%	0.0625%	1.0%	0.25%	0.0625%
No. 1	Areskap 100	29.8	30.0	36.0	1.4	1.3	1.9	+3.3	+3.2	−3.4
No. 2	Areskap 50	30.4	25.1	41.3	1.8	3.8	16.8	+2.3	−4.4	−23.6
No. 3	Aresket 300	32.1	32.2	38.6	4.8	4.9	6.2	−2.4	−2.6	−10.3
No. 4	Aresket 240	31.2	35.4	41.6	5.0	5.4	17.0	−1.7	−6.3	−24.1
No. 5	Aresklene 400	28.7	25.6	31.1	1.9	1.8	3.4	+3.9	+7.1	0.0
No. 6	Aresklene 375	28.6	32.1	34.2	1.9	3.6	10.3	+4.0	−1.2	−10.0
	Dihexyl sulfophthalate	29.8	30.2	31.7	6.7	7.2	9.4	−2.0	−2.9	−6.6
No. 8	Santomerse D	31.1	32.0	30.5	4.5	4.7	4.2	−1.1	−2.2	−0.2
No. 9	Santomerse S	32.7	34.7	39.0	6.3	9.3	14.5	−4.5	−9.5	−19.0
No. 10	Santomerse No. 3	31.0	31.7	32.7	3.9	4.8	4.7	−0.4	−2.0	−2.9
No. 11	Santomerse No. 3 paste	31.2	31.8	32.2	4.0	4.9	4.4	−0.7	−2.2	−2.1
No. 12	Santomerse No. 1	28.3	29.9	31.8	1.6	2.5	2.9	+4.6	+2.1	−0.2
No. 13	Santomerse No. 55	29.0	31.0	31.7	2.2	2.5	2.4	+3.3	+1.0	+0.4
No. 14	Santomerse B	31.8	32.8	34.0	5.3	6.7	9.0	−2.6	−5.0	−8.5
No. 15	Santomerse DT	25.4	25.5	25.4	0.1	0.1	0.1	+9.0	+8.9	+9.0
No. 16	Santomerse TIB	24.0	24.0	28.0	2.3	3.6	8.7	+8.2	+6.8	−2.2

Discussion of Agents:

Comparison of the data for Santomerse No. 3 (99 per cent active) and Santomerse No. 1 (40 per cent active, 60 per cent builder) illustrates the interesting and valuable effect produced by the addition of sodium sulfate (also sodium chloride) to surface-active agents. Since surface activity is increased by this addition, the term "builder" for added sodium sulfate is warranted, and this effect may be attributed at least in part to orientation of the surface-active agent at the interfaces involved.

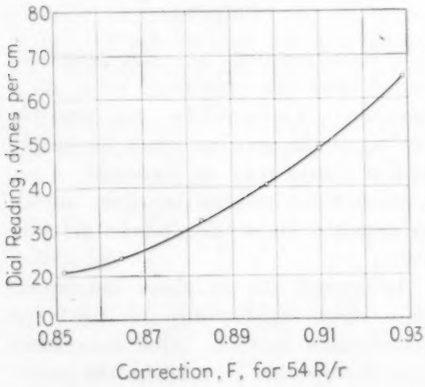


Fig. 1.—Correction Curve for Surface Tension Measurements.

Comparison of these data shows that Santomerse DT is perhaps the most surface active of the agents described, and that its activity level remains almost constant even at low solution concentrations. Santomerse TIB is likewise of interest because of its low surface tension and favorable spreading coefficient.

Examination of the Areskap, Aresket, and Aresklene series indicates that Aresklene (dibutylated, disulfonated hydroxy-diphenyl) is most active.

The generally high surface activity of these agents upon dilution indicates their potential utility for the wide variety of uses open to surface-active agents. Those materials with most highly positive spreading coefficients are potentially useful as insecticidal spreading agents and are most likely to be good emulsifying agents. Santomerse DT, the material with the most positive spreading coefficient is also an excellent emulsifying agent, as are others with positive spreading coefficients.

Lime Soap Dispersion

The synthetic surface-active agents will themselves form calcium and magnesium salts of varying degrees of solubility, and highly effective compounds will exhibit exceptional tolerance for these ions. A possible use for these agents is in combination with soda soap as a dispersant for subsequently formed insoluble soaps. This lime soap dispersing action has been put to use in the war effort since both the Army and Navy use certain synthetics in combination with soap in their all-purpose or sea-water detergents (**9, 10**). A further possibility is that these synthetics may be used to cleanse lime soap-containing garments, since these soaps may readily be removed either by solubilizing them or removing them by peptization or emulsification. In such cases high washing temperatures will have important effect upon degree of removal by the synthetic. Two possible conditions may thus be encountered: (1) Presence of large amounts of insoluble soap; (2) Presence of relatively light films of insoluble soap. Laboratory test conditions should be chosen which will duplicate the most severe conditions which will be encountered, so that relatively large amounts of lime soap should be present in the test medium.

These requirements are met by a dispersion test which was varied to fit the present needs. The general method followed is that described by Ramachandran, Uppal, and Venkataraman (**11**), but it has been modified suitably to test dispersing agents such as are encountered in industry.

Effective agents for this purpose will have dispersion numbers of from 10 to 40, although materials which will disperse the solution moderately well have dispersion numbers not greater than 80.

TABLE VII.—LIME SOAP DISPERSION.
The lower the number the greater the effectiveness.

	Sample	Dispersion Number	Comment
No. 1	Areskap 100	>80	Precipitate
No. 2	Areskap 50	>80	Curd
No. 3	Aresket 300	>80	Precipitate
No. 4	Aresket 240	>80	Precipitate
No. 5	Aresklene 400	>80	Precipitate
No. 6	Aresklene 375	>80	Precipitate
No. 7	Dihexyl sulfophthalate	20	
No. 8	Santomerse D	40	
No. 9	Santomerse S	>80	Precipitate
No. 10	Santomerse No. 3	20	
No. 11	Santomerse No. 3 paste	40	
No. 12	Santomerse No. 1	60	
No. 13	Santomerse No. 55	80	
No. 14	Santomerse B	20	
No. 15	Santomerse DT	10	
No. 16	Santomerse TIB	>80	

An example of an agent which has a low dispersion value and which has been used successfully in sea-water soaps is Santomerse No. 3. Other materials which are potentially useful for this purpose, provided that they are compatible with soap, are dihexyl sulfophthalate, Santomerse B and Santomerse DT. Agents which are not compatible with soap in the sense of lime soap dispersion are the Areskap, Aresket, and Aresklene series. Santomerse S is in too dilute a form to be effective according to this test, even though Santomerse D is useful.

Nonlathering agents may also be useful for lime soap dispersion (phosphates) but in cases where soap is actually regenerated, that is, by exchange of ions to form a soluble calcium or magnesium complex, a lesser amount of lime soap should be used or formed *in situ*, and the solution should be titrated with the regenerating agent to permanent lather, as in the American Public Health Assn. water hardness test.

Practical Wetting Tests

Since the usual surface and interfacial tension measurements limit the systems under investigation to liquid-air, liquid-liquid, or liquid-solid, more practical

systems may prove useful in evaluation. In these systems, capillarity may be a sufficient criterion of suitability, and the height to which the solution rises in a strip of fabric or paper may provide adequate comparisons. In these cases the interfaces involved may be liquid-solid-air-oil, but other materials may further complicate the picture.

Perhaps the textile industry was the first to recognize the utility of surface-active agents. Consequently, many attempts are recorded in the development of a practical, reproducible and truly applicable test. The practicability of the various tests may be undoubted, but reproducibility, and applicability of the test results to actual usage conditions are much harder to attain. A comparison (13) made between flannel squares, rosettes of loosely tied yarn, and the Draves-Clarkson test (14) in which skeins of yarn and a hook of specified weight are used, indicated that the latter test was the more effective. Another suggested test procedure is measurement of the contraction of skeins of yarn (15). The foregoing tests depend upon the measurement of the time required for a textile fabric or yarn to sink, wet out, or shrink, indicating displacement of air by solution. Other investigators (16, 17, 18) utilized a centrifugal method for measurement of actual moisture retained by the yarn which was considered a more suitable method for evaluation because it more closely approached actual usage conditions. Another evaluation procedure more recently suggested is that depending upon the measurement of the sinking time for 1 in. canvas disks immersed in the wetting agent solution in a standard manner (19).

Discussion:

All of these methods may be used with greater or lesser degree of reproducibility, but the Draves-Clarkson and canvas disk tests have in their favor simplicity of operation, minimum of equipment, and adequate reproducibility. Both methods are subject to variation in the standard fabric or yarn used in the determination, either as a result of aging or actual variation in the character of the manufactured article. They furthermore have been most widely used, and evaluation data on either basis are available from the literature. Either method provides data which, under careful control, can be used for the evaluation of comparative wetting efficiency, but their values are not directly comparable.

The three most effective agents are dihexyl sulfophthalate and Santomerse D and No. 3, if effectiveness at extreme dilution is the criterion used. Many of the agents show excellent and practically highly desirable results at the higher concentrations. It will be noted that again Aresklene (disulfonated, dibutylated hydroxy-diphenyl) is an improvement over the others of the Aresskap, Aresket, and Aresklene series. Santomerse S is a 30 per cent solution of Santomerse D so that at equivalent active ingredient concentrations they should provide nearly identical wetting results, and this is the case as may be seen by plotting the results on log-log coordinate paper or roughly comparing the results for Santomerse S at 0.25 per cent with those of Santomerse D at 0.0625 per cent.

Since all of the really effective materials have been used commercially with success, it might be difficult to decide which one to offer, but evaluation on the basis of the conditions to be met and upon efficiency simplifies the picture materially. The utility of the other general evaluation tests becomes apparent when a choice must be made between several materials almost identical otherwise.

TABLE VIII.—CANVAS DISK WETTING TEST.

	Sample	Wetting Time, sec.					
Concentration		0.5%	0.25%	0.125%	0.0625%	0.031%	0.015%
No. 1	Areskap 100	3.5	20.4	85.7	>180		
No. 2	Areskap 50	36.2	124.2	>180			
No. 3	Aresket 300	8.6	21.5	72.4	>180		
No. 4	Aresket 240	10.2	33.9	102.9	>180		
No. 5	Aresklene 400	2.0	4.6	17.7	104.8	>180	
No. 6	Aresklene 375	2.5	9.8	28.9	137.9	>180	
No. 7	Dihexyl sulfophthalate	2.0	3.2	11.0	38.2	93.2	>180
No. 8	Santomerse D	2.2	4.6	14.4	35.2	126.6	>180
No. 9	Santomerse S	10.0	33.3	>180			
No. 10	Santomerse No. 3	3.9	7.5	14.9	48.7	131.7	>180
No. 11	Santomerse No. 3 paste	5.1	10.6	21.4	54.2	>180	
No. 12	Santomerse No. 1	6.1	16.0	63.2	141.5	>180	
No. 13	Santomerse No. 55	6.1	12.6	29.9	117.2	>180	
No. 14	Santomerse B	34.7	76.1	139.0	>180		
No. 15	Santomerse DT	8.6	17.2	73.8	>180		
No. 16	Santomerse TIB	Inst.	7.6	164.7	>180		

TABLE IX.—DRAVES-CLARKSON TEST.

	Sample	Wetting Time, sec.					
Concentration		0.5%	0.25%	0.125%	0.0625%	0.031%	0.015%
No. 1	Areskap 100	10.9	38.7	>180			
No. 2	Areskap 50	82.5	>180				
No. 3	Aresket 300	11.6	23.1	78.4	>180		
No. 4	Aresket 240	17.7	45.0	>180			
No. 5	Aresklene 400	2.6	6.6	18.2	90.4	>180	
No. 6	Aresklene 375	6.2	12.6	52.3	>180		
No. 7	Dihexyl sulfophthalate	1.5	3.8	6.8	16.3	79.3	>180
No. 8	Santomerse D	3.3	5.4	11.3	36.4	>180	
No. 9	Santomerse S	8.4	31.0	110.3	>180		
No. 10	Santomerse No. 3	4.3	5.7	13.4	32.5	85.7	>180
No. 11	Santomerse No. 3 paste	4.9	8.7	16.9	45.6	107.5	>180
No. 12	Santomerse No. 1	7.5	16.0	43.0	123.8	>180	
No. 13	Santomerse No. 55	5.3	10.7	17.4	120.4	>180	
No. 14	Santomerse B	32.5	39.6	51.0	95.2	>180	
No. 15	Santomerse DT	15.6	38.8	92.8	>180		
No. 16	Santomerse TIB	Inst.	6.4	135.1	>180		

Lather Values

The relative lathering action of surface-active agents is obviously important with detergents and wetting agents used largely for their foaming action. Soap, as the time-recognized detergent, foams profusely in soft water or even in hard water if a sufficient amount is present to overcome both water hardness and the insoluble soap formed. As a consequence, foam is now considered as a requisite to detergent action. Many detergent adjuncts, which are detergents in their own right, produce no foam. These adjuvants are the alkaline salts such as the carbonates, silicates, borates, and phosphates. The fact that these materials did not foam disproved the theory that foam was useful as a measure of detergency, but the volume of foam formed is still a very valuable property of surface-active materials. Ability to foam at extreme dilution or under adverse conditions may be an important factor in application. The use of wetting agents which foam, to show the presence of leaks in pressure equipment is well known. A layer or blanket of foam on electro-pickling apparatus reduces the hazard of work-

ing with acid baths. Wetting agents have been used in the wash water of conditioning systems to remove foreign substances, but excessive foam would be a liability rather than an asset. Surface-active agents used in emulsion or powder paints should improve spread and aid in rinsing from the brush, but should not foam so much as to cause bubbling and unevenness of the coating. These are but a few of the many applications for foaming agents but illustrate the conditions which control their usage.

Many methods for measuring foaming characteristics of compositions have been devised. From the consideration of equipment involved they may be classified as follows:

1. Bubble cylinder (20).
2. Manual manipulation of closed container (21).
3. Capillary under constant pressure (22).
4. Solution drop, open cylinder.
5. Mechanical agitation in closed vessel (24).

The subject of foams is a complicated one, but for many purposes a measurement of foam height will suffice as a means for comparison. The method often used in the absence of other equipment is to shake a volume of solution in a stoppered graduate in a standard manner, and measure the foam formed. This method provides only a rough estimate, since a variation of ± 15 per cent is about the best that may be expected under very carefully controlled conditions.

In our estimation, the most satisfactory method for the evaluation of foaming agents is that developed by Ross and Miles (23). This test is easy to make, the equipment is relatively inexpensive, outside variables are reduced to a minimum, and reproducibility is good. Although the test data shown in Table X are given at only one concentration, it was chosen because at this point maximum differences between samples can be demonstrated. Careful evaluation will require tests over a range of concentrations.

Discussion:

The effect of dilution upon lather will be noted by observing the results obtained with the pure and dilute agents of the Areskap, Aresket, Aresklene series, Santomerse D and S, and Santomerse Nos. 3 and 1.

It is interesting to note the effect of sodium sulfate upon the lather of Santomerse No. 1 in soft water. Here again, increased surface activity is produced by addition of an inert salt to a much reduced concentration of active ingredient. The effect is not so marked in hard water because the effective concentration is below optimum for the dilution of the active ingredient.

TABLE X.—LATHER VALUES.

	Sample	Lather at 25 ± 0.2 C. in 0.05 per cent Solution, cm.			
		50 ppm. Soft Water		300 ppm. Hard Water	
		At once	After 5 min.	At once	After 5 min.
No. 1	Areskap 100	8.3	7.2	9.8	8.7
No. 2	Areskap 50	2.9	1.6	3.8	2.3
No. 3	Aresket 300	14.0	12.7	11.1	9.5
No. 4	Aresket 240	9.1	7.9	8.0	5.8
No. 5	Aresklene 400	8.4	6.4	8.5	6.3
No. 6	Aresklene 375	7.1	5.2	4.6	3.3
No. 7	Dihexyl sulfophthalate	17.5	15.9	14.6	11.2
No. 8	Santomerse D	13.4	12.9	13.2	12.1
No. 9	Santomerse S	11.6	10.2	10.4	9.4
No. 10	Santomerse No. 3	13.2	12.8	13.5	12.8
No. 11	Santomerse No. 3 paste	12.1	11.7	11.7	11.0
No. 12	Santomerse No. 1	15.7	15.1	9.8	9.4
No. 13	Santomerse No. 55	16.6	14.9	12.4	11.2
No. 14	Santomerse B	14.7	11.8	12.2	11.5
No. 15	Santomerse DT	12.4	10.8	10.6	9.4
No. 16	Santomerse TIB	trace	none	trace	none

TABLE XI.—SOLUBILITY IN ORGANIC SOLVENTS.

	Sample	Solubility, per cent by weight at 25 ± 3 C.		
		Carbon Tetrachloride	Acetone	Stoddard Solvent
No. 1	Areskap 100	<0.07	<0.14	<0.14
No. 2	Aresket 300	<0.07	<0.14	<0.14
No. 3	Aresklene 400	<0.07	<0.14	<0.14
No. 4	Dihexyl sulfophthalate	5.8	38.7	<0.14
No. 5	Santomerse D	<0.07	<0.14	<0.14
No. 6	Santomerse No. 3	<0.07	<0.14	<0.14
No. 7	Santomerse B	<0.07	<0.14	<0.14
No. 8	Santomerse DT	13.4	38.7	41.0
No. 9	Santomerse TIB	<0.07	<0.14	<0.14

The anionic synthetic detergents will form salts of varying degrees of solubility and these will foam to greater or lesser extent. Consequently, hard water (calcium or magnesium ions) will have more or less effect upon the lather of the sodium salts. In some cases, the calcium and magnesium ions may depress foam formation, in others foam may be increased, while in still others no change will be observed.

In many instances a wetting agent is required which will foam only moderately or preferably not at all, and Santomerse TIB provides such an effect.

Organic Solvent Solubility

In spite of the presence of polar groups, many compounds are soluble in nonpolar solvents. Their possible applications under these conditions are in paints, dry cleaning solvents, insecticides, printing inks, and as self-emulsifying agents.

Since the surface-active agent generally is added to produce some given effect, it is not necessary that solubility be determined under conditions of greatest accuracy: small amounts of agent are generally sufficient or must be maintained. It is therefore felt that the accuracy of method used is entirely adequate.

Only the pure materials are evaluated or this purpose, since even traces of inorganic salts or of water will reduce actual or apparent solubility. Of the materials tested, only dihexyl sulfophthalate and Santomerse DT are markedly soluble in carbon tetrachloride, acetone or Stoddard solvent, and only Santomerse DT is soluble in the latter solvent.

Other solvents may be used in this test when further information is desired, although chlorinated hydrocarbons, a polar solvent, and a hydrocarbon are represented.

Detergent Test

The difficulty which has been experienced in standardizing a detergent test is evident in the records of the American Oil Chemists Society and more recently the American Society for Testing Materials. In spite of apparent inability to standardize such tests which comprise a "standard soil" and a standard washer, the American Association of Textile Chemists and Colorists are considering an approach from the textile mill standpoint utilizing another type of "standard soil," fabric, and scouring device. Consequently, it appears that in spite of reverses, it is felt that ultimately a test method will be devised which can be fully controlled.

The multitude of variables encountered in this work accounts for the inability of workers to produce results which can be considered as check values. The first problem is the "standard soil" itself: The "soil" chosen should be of constant composition and the constants of the soiling agents should be controlled. Treatment during or after application of the "soil" may have profound effect upon uniformity and ease of removal: The presence of moisture in the fabric or resulting from evaporation of the diluent suspending agent may influence uniformity, while humidity and temperature during drying or aging, (either natural or induced) will affect results. All these variables

TABLE XII.—DETERGENCY.

0.2 per cent Concentration. Santomerse No. 1 as 100 per cent Detergency.

	Sample	Per Cent Active	Detergency, per cent		Solutions			
			50 ppm. Soft Water	300 ppm. Hard Water	50 ppm. Soft Water		300 ppm. Hard Water	
					Lather, in.	pH	Lather, in.	pH
No. 1	Areskap 100	100	25	14	¼	7.3	¼	7.4
No. 2	Areskap 50	50	33	15	0	7.1	0	7.1
No. 3	Aresket 300	100	33	14	1	6.5	tr.	6.4
No. 4	Aresket 240	40	30	1	⅛	6.7	0	6.6
No. 5	Aresklene 400	100	16	31	2	6.9	2	6.8
No. 6	Aresklene 375	75	10	13	1	7.0	½	6.9
No. 7	Dihexyl sulfophthalate	100	85	81	4	5.6	4	5.4
No. 8	Santomerse D	100	89	104	4	6.2	4	6.4
No. 9	Santomerse S	30	26	22	⅛	5.7	⅛	6.0
No. 10	Santomerse No. 3	100	104	111	4	6.3	4	6.3
No. 11	Santomerse No. 3 paste	75	89	106	4	6.2	4	6.1
No. 12	Santomerse No. 1	40	100	100	4	6.6	4	6.6
No. 13	Santomerse No. 55	55	91	91	4	6.6	4	6.6
No. 14	Santomerse B	100	79	99	4	6.6	4	6.5
No. 15	Santomerse DT	100	94	115	4	9.1	4	9.4
No. 16	Santomerse TIB	100	54	97	0	5.8	tr.	5.8

must be considered, and controlled, to produce "standard soil." The fabric weave chosen to receive the soil may have considerable bearing upon the actual removal of the soil. Other fabric variables are differences in weave in the same bolt, or bolts from different machines, or from the same machine manufactured at different times, fiber variation with source, mechanical or chemical treatment, desizing treatment, and either chemical or physical conditioning prior to application of soil.

The machine used for washing the fabric should control such factors as temperature, volume of wash liquor, and mechanical action during the washing operation. Other factors which must be controlled are time of wash, water hardness, solution concentration, rinsing, and drying.

Once the fabric has been processed, some measurement of soil removal must be made. Weight loss and extraction of the fabric have for the most part been displaced by actual measurement of soil removal (whiteness) by photometric reflectometer readings. A number of suitable reflectometers are available, any of which may be used for this purpose. The photometric measurement of soil removal is perhaps more free from variation than other portions of the test but even here the surface condition of the fabric, the fabric backing, the area and size investigated, and the sensitivity of the photometer may considerably influence results.

Under the foregoing conditions it is perhaps not unusual that many investigators should decide that control would be virtually impossible, and that the only true measurement of suitability would be actual trial. Resort to the practical method indicates utility but seldom furnishes a numerical measure of results. Consequently there is definite need for a laboratory screening test which is of sufficient reproducibility that confidence may be placed in the results obtained. Such a test however will not replace actual trial under controlled conditions, but will save much time, and when correlation may be developed between laboratory and actual usage, the laboratory test may be used to indicate practical utility.

It may be expected that the reports in this field may include more practical tests made in small-scale or full-size equipment. Such data will avert the criticism regarding the Launderometer, but will require considerably more expenditure of test time. There still remains the question of a "standard" soil, and those who wish to quibble may still complain on this point. With increasing knowledge of the factors involved in preparation, a "standard" soil may yet be devised, but once standardization has been attained, other "soils" will of necessity be investigated.

Another tool which has not been used sufficiently, and which may profitably be applied to detergent test work is statistical analysis of the test results obtained.

Discussion:

The conditions under which these detergent tests have been made were as fully controlled as possible. Examination of the test results obtained will indicate that the test has merit as a means for differentiating between compositions of widely varying cleansing characteristics. It has long been recognized that the Areskap, Aresket, and Aresklene series are poor practical cleansers, and this checks well with the detergent results. Inasmuch as there is only 30 per cent active ingredient in Santomerse S, it might be expected that comparatively it would be inferior to Santomerse D. As a matter of fact one method for comparison of agents is to develop a detergency—concentration curve which will indicate the limits of cleansing activity when used below their range of practical utility.

A verification of the utility of this wash test is the fact that both practical usage and laboratory evaluation have demonstrated the excellent detergence of Santomerse Nos. 1, 55, and 3.

It will be noted that several of these materials, for example Santomerse No. 3, Santomerse D, Santomerse B, DT, and TIB, exhibit less detergent activity in soft than in hard water. Apparently therefore, the presence of soluble calcium and magnesium salts results in at least partial metathesis, the resultant surface-active products exhibiting increased detergency.

The lather values shown are those observed in the pint Launderometer jars, so that the lather height can never be greater than 4 in.

It is interesting to note that although Santomerse TIB produces practically no lather, in hard water it exerts excellent detergency.

The foregoing discussion illustrated by the evaluation data for the surface-active agents has demonstrated the utility of the various methods. As a convenience the methods have been segregated rather than included in the body of discussion.

EDITORS NOTE.—The complete list of references and the methods will appear in the August ASTM BULLETIN

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Federal Specifications Board

SECRETARY Vinson of the Treasury Dept. has recently announced the formation of a newly created Industry Advisory Council to the Federal Specifications Board. The chairman of this Council is Howard Coonley, chairman of the Executive Committee of the American Standards Assn., and among those serving on the Council will be C. L. Warwick, Executive Secretary of A.S.T.M. Formation of this Council is a further step in securing better cooperation between the Federal Specifications Board and other specification-writing bodies in industry. The Board was reestablished last August by Clifton E. Mack, Director of the Treasury Department's Procurement Div., and it replaces the former Federal Specifications Executive Committee. This reorganization has been effected under the direction of Willis S. MacLeod, acting deputy director, under Mr. Mack.

An interesting meeting of approximately 800 members of the 72 Federal Specifications Board's Technical Committees was held in Washington on March 19 in the auditorium of the Labor Dept. building. At this meeting, after introductory remarks by Mr. Mack, Mr. MacLeod explained to those present the new plan for the operation of the Specifications Board's Technical Committees. Mr. Coonley also spoke on bringing cooperation of industry into the important coordination job ahead. At the meeting Mr. MacLeod also emphasized recent work which certain of the Technical Committees have done in paint, plastics, textiles, electrical supplies, packaging, etc. Mr. MacLeod is Executive Vice-Chairman of the Federal Specifications Board and takes over the duties formerly carried on by N. F. Harriman of the FSEC who retired a few months ago after many years of active service in this field.

Increase in Bulletin Subscription Rates

EFFECTIVE with the May, 1946, BULLETIN there has been an increase in the BULLETIN subscription rate from $1.50 per year (six issues) to $2.00 annually. This price is effective in the United States and its possessions. For Canadian subscriptions, the rate is $2.25 and for foreign $2.50 yearly. The single subscription price remains at 50 cents per copy.

There has been a steadily mounting increase in the volume of technical material published in the BULLETIN and there have been more news accounts of activities relating to standardization and research and other material. The Executive Committee was cognizant of the increase in the amount of material published in establishing the new subscription rates.

The officers feel that the BULLETIN is a very valuable medium in keeping our members in touch with Society developments, giving currently technical papers and related material that are of concern to large groups of the members. It is the hope that the expansion of the BULLETIN will continue and that before long the number of issues per year may be increased from the present six issues at approximately bimonthly intervals.

Numerous Recommendations on Chemical Analysis of Metals Approved by Standards Committee

IT WILL be noted from the accompanying table that 13 recommendations emanating from Technical Committee E-3 on Chemical Analysis of Metals have been approved by the Society's Committee on Standards. These actions were cleared on March 30 and April 26.

All of these new and revised methods will be published in the 1946 Volume on Chemical Analysis of Metals on which active work is now under way. In the near future, each member will be given the opportunity to request a copy of the publication and also to order extra copies at special prices to members.

In addition to work on new standards, the personnel of this committee has devoted a great amount of time and effort in bringing the various procedures already standardized up to date and in line with latest practice, in many cases incorporating short cuts and more rapid procedures. The greatly increased 1946 volume will indicate to some extent the notable work the committee has been carrying on.

Notes on Methods:

The new Method for Polarographic Determination of Lead and Cadmium in Slab Zinc (Spelter) (E 40 – 46 T) establishes a procedure which is very rapid and highly accurate and is a result of the committee's conclusion that for these particular elements polarographic analysis has very definite advantages. Methods of Chemical Analysis of White Metal Bearing Alloys (E 57 – 46 T) were published first in 1943 as information and on the basis of experience since that time some changes and additions have been made.

Photometric Methods for Chemical Analysis of Copper and Copper-Base Alloys (E 62 – 46 T) in one sense supplement the so-called "wet methods." Here again these particular procedures offer many advantages, including speed and accuracy.

Comments similar to those on E

62 also apply to the new Photometric Method for Determination of Iron in Lead and Tin-Base Alloys (E 67 – 46 T).

Concerning the new Method of Chemical Analysis for Sulfur in Steel by Direct Combustion (E 30 – 46 T); the widespread use of the direct combustion method for determining sulfur in steel led the committee to establish standardized techniques, apparatus, etc. There was considerable demand for a standard since the combustion method now compares favorably in accuracy with the gravimetric procedure and it is much more rapid.

The tentative methods for use of the photometer for analysis of magnesium and its alloys, the determination of iron in slab zinc and iron in copper-nickel alloys now make available in standardized form the advantages which photometric methods offer for these particular procedures. The procedures for analyzing special brasses and bronzes (E 54 – 46 T) have been published for the past three years as information and now with some changes have been approved as tentative.

With the increasing emphasis on the utility and use of photometric methods, it would, of course, be very desirable that Committee E-3 present information covering the proper use of the methods they have been developing and that has been done through the Recommended Practice for Photometric Methods for Chemical Analysis of Metals (E 60 – 46 T).

In addition to their inclusion in the new volume on Chemical Analysis of Metals, these new and revised methods will be made available in separate pamphlet form but may not be available for distribution until about August 1.

Actions on Chemical Analysis of Metals

NEW TENTATIVES

Method of Chemical Analysis for Sulfur in Steel by Direct Combustion (E 30 – 46 T)

Method for Polarographic Determination of Lead and Cadmium in Slab Zinc (Spelter) (E 40 – 46 T)

Methods of Chemical Analysis of Special Brasses and Bronzes (E 54 – 46 T)

Methods of Sampling Wrought Non-Ferrous Metals and Alloys for Determination of Chemical Composition (E 55 – 46 T)

Methods of Chemical Analysis of White Metal Bearing Alloys (E 57 – 46 T)

Recommended Practice for Photometric Methods for Chemical Analysis of Metals (E 60 – 46 T)

Photometric Methods for Chemical Analysis of Magnesium and Magnesium-Base Alloys (E 61 – 46 T)

Photometric Methods for Chemical Analysis of Copper and Copper-Base Alloys (E 62 – 46 T)

Photometric Method for Determination of Iron in 70–30 Copper-Nickel Alloy (E 63 – 46 T)

Photometric Method for Determination of Iron in Slab Zinc (Spelter) (E 64 – 46 T)

Photometric Method for Determination of Iron in Lead and Tin-Base Alloys (E 67 – 46 T)

REVISION OF TENTATIVES

Standard Methods of Chemical Analysis of Ferro-Alloys (E 31 – 42) and its reversion to tentative (E 31 – 46 T)

Recommended Practices for Apparatus and Reagents for Chemical Analysis of Metals (E 50 – 46 T)

Leroy C. Gilbert Joins A.S.T.M. Staff

WE ARE pleased to announce the addition to the headquarters technical staff of Mr. Leroy C. Gilbert who joins the staff after completing over five years' active duty in the Corps of Engineers, U. S. Army, during which time he was promoted to the rank of Colonel. Previous to his period of service he was active in technical and research work for the France Stone Company Laboratories with headquarters in Toledo.

Mr. Gilbert's appointment is in line with the policy of expanding the staff to provide closer contacts with our technical committees, and his particular interest will be those groups functioning largely in the building materials field including the "C" committees and some of the "D" group.

It is in this field of building materials that Mr. Gilbert has had his chief experience. A graduate of the University of Cincinnati where he took the Cooperative Civil Engineering Course, he became associated with the France Stone Company Laboratories following his graduation in 1928, serving until being ordered to active duty in the Corps of Engineers in February, 1941. His work with the company included survey activities, construction engineering, testing and research on all types of road and construction materials.

In the Corps of Engineers he had very wide experience on a variety of problems, spending a number of months on maneuvers in the South and West, later was assigned to Headquarters, Army Ground Forces, in Washington, as Assistant Ground Engineer, and then went overseas as Engineer Member of an Observer Board in the Italian theater. For his services as Assistant Ground Engineer and as an Engineer Observer overseas he was awarded the Legion of Merit.

In his industrial work he had come in contact with quite a large number of A.S.T.M. members, many of whom are active in the work of the Society's technical committees, and has participated in research work for A.S.T.M. projects. Mr. Gilbert joined the staff on April 1, has been familiarizing himself with a multitude of details and mechanics of staff functioning, and has already made contacts with several of the committees.

100th Anniversary of the Pennsylvania Railroad

Company Closely Linked to Society

AS WE note with great pleasure the celebration by the Pennsylvania Railroad of its 100th anniversary, it is interesting to follow the close relationship that the A.S.T.M. has had with the progress of the company during the last fifty years of that period.

Since the incorporation of the A.S.T.M., and even previous to that time when the Society was a part of the International Association for Testing Materials, a succession of Pennsylvania Railroad chemists, mechanical and testing engineers have participated actively in the work of the Society. These representatives have served and are now serving on numerous technical committees and in several instances

have held high office in A.S.T.M.

One of the earliest representatives was Paul Kreuzpointner who served as Treasurer of the American section of the international organization from 1898 to 1900.

Probably the most widely known, nationally and internationally, and most highly esteemed and beloved representative was Charles B. Dudley. Dr. Dudley was one of the original charter members of the Society and served as its first President from 1902 up to his death in 1909. He was not only a pioneer in the field of standardization of testing but he contributed greatly to the technical advancement of the Pennsylvania Railroad. His contributions were of permanent value to the railroad, extending far beyond the bounds of the laboratory which he founded at Altoona in 1875. Such problems were his to solve as the fabrication of steel rails suited for hard wear and yet not liable to fracture; the lighting, heating and ventilating of passenger cars; the construction of wheels and axles; the analysis of coals and oils; the examination of water supplies, both for drinking and boiler purposes; and the transportation of explosives and other hazardous materials.

Coming down through the years of progress other Pennsylvania men have made their contributions to the Society. Space does not permit listing their many accomplishments. Alfred W. Gibbs, while Chief Mechanical Engineer, Philadelphia, was President of the Society from 1914 to 1915; C. D. Young, as General Supervisor of Stores, Philadelphia (now Vice-President, Penna. R.R.), occupied the Presidency from 1921 to 1922; F. M. Waring, then Engineer of Tests, Altoona, held office on the Executive Committee in 1936; M. E. McDonnell, Chief Chemist (now retired), Altoona, was voted an Honorary Member of the Society in 1944; and L. B. Jones, present Engineer of Tests, Altoona, is presently a member of the Executive Committee and active in the work of several technical committees, notably Committee A-1 on Steel.

The long record of progress of the Pennsylvania Railroad, with the participation of its technical men in the work of the Society, is just one outstanding example among many of the influence and relationship the Society has had in all forms of industry and enterprise. The Pennsylvania Railroad is one among many of the railroads of the country holding active membership in the Society. It can be truly said that the purpose of the Society in "promoting knowledge of the materials of engineering, and the standardization of specifications and the method of testing" has come hand-in-hand down through the years with the progress of such institutions as the Pennsylvania Railroad.

Notes on Important Publications

Proceedings
Chemical Analysis Volume
Index to Standards
Standards on Copper Alloys
Binders for Separate Standards
Adhesives Symposium
Atmospheric Corrosion
Quality Control

EVEN if a complete new Book of A.S.T.M. Standards were not scheduled for publication late this year, the Society would still have a very heavy publication program. In the following material attention is directed to certain books that have been or shortly will be issued, and others that are scheduled for completion within the next few weeks.

Members are urged to read the following news notes.

1945 Proceedings:

While the title of this publication remains essentially the same, those members of the Society who have been following the new policy on publication of papers know that much of the material including many technical papers was not presented at the 1945 Annual Meeting (this was an abbreviated business session). However, this book is always more than the proceedings of a meeting and it represents one of the Society's most important and valuable annual books. It is aimed to give members for their permanent files a complete picture of committee actions and activities for the year, and to present the technical papers which are considered by the Administrative Committee on Papers and Publications in the nature of permanent reference material. The extensive discussion of the papers, which frequently adds a great deal to a complete understanding of a subject, enhances the value of the *Proceedings*.

The 1945 *Proceedings* aggregates about 1070 pages, of which about 400 are devoted to reports of technical committees including considerable appended material. Some report material in the final book was not preprinted and hence this is the first time members will have seen the items. Included in this category are Report of Technical Committee A on Gasoline, Report on Short-Time Tests for Sulfate Resistance of 121 Commercial Cements (Committee C-1), the Results of a Questionnaire on Tests on Transformer Oil in Service (Committee D-9), the Report of Committee E-3 on Chemical Analysis of Metals, and a Summary of Test Results Obtained on Flexural Properties of Plastics (Committee D-20).

All except three of the technical papers, which section of the *Proceedings* comprises by far the greater part, about 700 pages, were issued to the members in advance either as preprints or as BULLETIN papers. The exceptions were "The Effect of Repeated Loading on the Bond Strength of Concrete" by C. W. Muhlenbruch, and two papers by John Tucker, Jr.: "Effect of Di-

mensions of Specimens Upon the Precision of Strength Data" and "The Maximum Stresses Present on the Failure of Specimens of Brittle Materials."

A copy of the *1945 Proceedings* is being mailed to every member of the Society who was in good standing, and extra copies can be purchased at $6.00 per copy. To nonmembers, the price is $9.00, in blue cloth binding. The binding charge for half-leather is $2.00 extra.

1946 Volume on Chemical Analysis of Metals:

This volume, to be reissued for the first time since 1943, will be a greatly amplified book, perhaps running well over 500 pages, compared with the 300 in the current volume, and will provide an up-to-date compendium of the practices on methods of analyzing a wide range of ferrous and non-ferrous metals. It will be particularly significant because of the inclusion of much new material including procedures for colorimetric and polarographic analysis. Some idea of the new and revised material to be included can be gained from the news account in this BULLETIN announcing recent actions by the Standards Committee, all of which resulted from the work of Committee E-3 on Chemical Analysis of Metals.

Index to Standards:

This publication, a very valuable one even though it is distributed without charge, is intended to facilitate the use of the Book of Standards, and in fact it is almost an essential part of the big books and the Supplements. It is designed to give references to the A.S.T.M. publications where all of the specifications and tests are printed in their latest approved form. The main portion of the Index lists the specifications under appropriate key words but use is made of convenient cross references so that the material will be as concise as possible. Under each key heading an effort is made to select the most significant word in the title of the specifications so that there is some alphabetical sequence.

A most valuable part of the Index is the list of standards in numeric order of their serial designations, and in these lists, too, reference is made to the official source of latest publications. The Index thus is of real service to a large number of the members who talk about standards and find their location by designation alone, and also to the other group of members and nonmembers who are not so well acquainted with designations but more concerned with titles.

A copy of this latest Index to Standards issued yearly (Dec., 1945) has been sent to each member and committee member of the Society, and in addition the large and growing mailing list of nonmembers who either are purchasers of the Book of Standards or are concerned with specifications work, will have received the Index. Extra copies are available on request. A number of organizations get several copies to distribute to their key technical people.

We recommend that this Index be placed convenient to the Book of A.S.T.M. Standards. Its use will save much time in locating any particular items the locations of which are not known.

Symposium on Adhesives:

The seven technical papers comprising this symposium were presented at an Atlantic City meeting sponsored by Committee D-14 on Adhesives. Five of the contributions were prepared by subcommittee officers and embody not only their own thoughts but represent a consensus of the membership of their subcommittees, the personnel of which, of course, constitute leading technical authorities in this field. In his introduction to the symposium, Eugene R. O'Hare, Technical Director, Casein Company of America, who served as chairman of the committee in charge and presided at two sessions, points out that

". . .all members who worked so hard and so skillfully in the preparation of this, the committee's first symposium, did so with the consciousness that theirs was the pioneering effort on behalf of the committee, sure to influence, for better or for worse, the future activities and effectiveness of the committee.

"This responsibility for laying the foundations, as it were, for future work to follow was a serious one, and seriously taken, as the selection of the papers' subject matter and their treatment will evidence; but more than this was involved.

"As the committee's work proceeded, a curous paradox became more and more evident, which was that the whole field of adhesives had been "growing up" almost by leaps and bounds as the urgency of the war broadened the horizons of organic chemistry so that in one direction adulthood seemed just around the corner, while in another vestiges of childhood, or at best adolescence, lingered.

"Specifically, much more had been learned about the formulation of new adhesives, and about their practical application to new jobs which the older adhesives had not been equal to, than there had been found time to digest and record in the technical literature.

"Some inadequacies in testing methods for instance, and questions of nomenclature, and problems of the classification of adhesives, emphasized this, and pointed up also the importance of the committee encouraging the widest possible participation in its work, not only within the A.S.T.M. but from the technicians in all the growing list of industries to which adhesives are becoming more important.

"The growth of Committee D-14 has been gratifying, and also the responses to its efforts; and it is hoped that this symposium may serve to encourage and broaden this interest, as perhaps the best means of insuring further progress."

Copies of this symposium in heavy paper cover, the whole comprising about 70 pages, can be obtained after June 15, for 75 cents per copy. The nonmembers' price is $1.00 per copy. It is expected a convenient order form will be sent to the members in the near future.

Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals:

Work is under way, and in fact several of the papers are in type, in connection with this symposium held as one of the technical features of the 1946 Spring Meeting in Pittsburgh. Further announcement will be made concerning this publication which will be available to members at special prices. It is a particularly significant publication, making available for the first time in convenient correlated form a critical evaluation and interpretation of the vast amount of data which were developed in the exposure tests sponsored by A.S.T.M. Committee B-3 at various locations throughout the United States and outside the United States, many of which re-

search programs extended over several years.

Standards on Copper and Copper Alloys:

This 1946 special compilation will provide in their latest approved form all of the Society's specifications and tests which cover copper and copper alloys. The great majority of the standards have been developed by Committee B-5 but there are a number of standards from other groups including B-1 on Electrical Conductors. The whole book is expected to comprise close to 500 pages and will be available to members at $2.20 in heavy paper binding; nonmembers' price $3.25 per copy. This should be ready for distribution about June 15.

Symposium on Statistical Quality Control:

Primarily this symposium comprises two very interesting technical papers presented at the Spring Meeting in Pittsburgh: one by Messrs. Goffman and Manuele of the Westinghouse Electric Corporation, on the "Use of Statistics in Writing Specifications;" the other, an intriguing discussion of statistical methods under a caption "Dollars for Your Thoughts" as prepared by Colonel Leslie E. Simon, Aberdeen Proving Ground, Maryland. Several other authorities presented discussion and it is planned to reprint the two technical papers from the March BULLETIN where they were first published, with the discussion, and the booklet will be thus available separately; copies can be obtained by members at 35 cents, the nonmembers' price being 50 cents.

Binders for Separate Standards:

Members are reminded that all separates, that is, the specifications and test methods as reprinted in separate pamphlet form, are now being punched to fit a standard 3-hole binder. Many of those who use A.S.T.M. specifications find it convenient to have available special groups of the standards in separate pamphlet form which they can easily carry with them or refer to conveniently in their office. Excellently constructed expanding post-type binders, which open flat, are available in two sizes: one with a capacity of about 400 pages (an average of, say, 60 standards), and a larger size which will hold about 800 pages or about 120 standards. Each binder is priced at $2.25 and has a gold stamped back-strap reading "Selected A.S.T.M. Standards."

The regular prices for separate copies of specifications apply in connection with these binders, namely 25 cents each in lots up to 9; 20 cents per copy for 10 to 24; $17\frac{1}{2}$ cents for 25 to 99, and prices are quoted on 100 copies or more. These prices incidentally apply on all our standards whether they are the same document or assorted.

From the foregoing material it can be seen that Headquarters is in the midst of a very intensive publication program *but* a number of other books are in the offing about which further announcement will be made.

President and Executive Secretary at Southern California Meeting

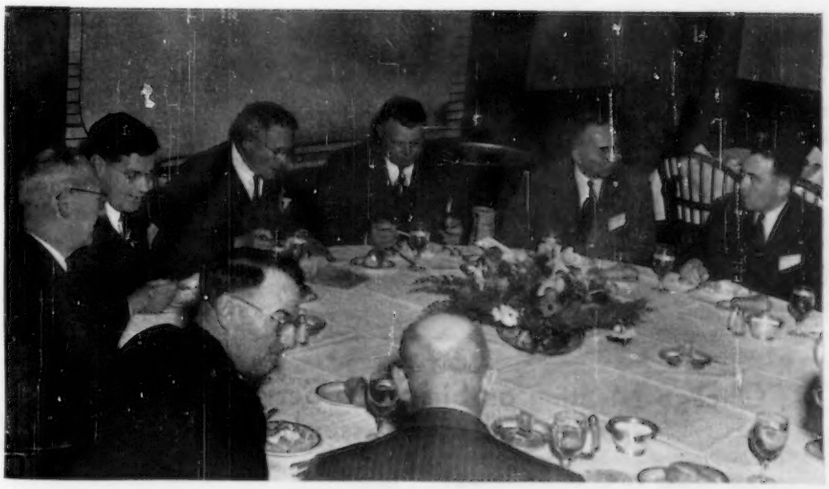
PRESIDENT John R. Townsend gave an interesting address on "Materials Engineering at Home and Abroad," and Executive Secretary C. L. Warwick spoke on "A.S.T.M. Consumer Goods Program and Service Testing" at the district meeting in Los Angeles on Tuesday, March 19. The meeting, arranged by the Society's Southern California District, was attended by about 150 members and guests. District Chairman E. O. Slater, Smith-Emery Co., and District Secretary H. W. Jewell, Pacific Clay Products, developed plans for the meeting, with other members cooperating closely. Since the paper is printed elsewhere in this BULLETIN (see page 19), it may suffice here to point out that Mr. Townsend, in commenting on the continuing upsurge of the West Coast as an industrial area, said that materials engineering had had an important part in the various developments, and that the exchange of ideas and cooperation among the engineers and their associates was most important. This is true particularly since some of the production problems required "radical revision of our knowledge of materials and fabrication." He stressed the need for simplification in connection with various grades and classes of materials, mentioning examples from his own interesting experiences, of successful applications of materials engineering. He stressed the necessity of supporting fundamental research to develop new tools, and indicated that the engineer, as differentiated from the fundamental research expert, must know how to measure and use materials, and be able to assure a uniform level of quality. He also mentioned again the paramount importance in the past of our American production know-how in contrast with the German lack of knowledge of applied modern high-speed processes and control.

Mr. Warwick prefaced his discussion which dealt largely with the work of some of the newer developments in A.S.T.M. such as the consideration of consumer goods testing, the work on simulated service testing, parts and assemblies, etc., by stating how quickly the Society had reconverted to a postwar program. Emergency specifications and tests had been dropped or embodied in regular standards, and the Society was receiving a really tremendous volume of technical papers and reports, much of the data having been under wraps until peace came. This will result in important publications and very extensive meetings.

He mentioned some of the relatively recent activities, including the work on metal powders, adhesives, and the new technical committee on quality control of materials. This subject was very important in implementing our production. (NOTE.—Two interesting papers on statistical quality control appeared in the March BULLETIN.) With respect to work on evaluation

of parts and assemblies and simulated service testing, he pointed out that testing of materials as such, by the use of samples and test specimens, may not give us a sufficiently complete evaluation of their properties. In two industries particularly, aircraft and automotive, the testing of parts and assemblies by simulated service or in actual performance has been essential. Obviously, the design engineer may need much more information than that provided by materials tests, and since it has been considered the proper function of A.S.T.M. to aid in obtaining all information about materials that a design man may want, it was decided to extend the work actively to involve testing of parts and assemblies. Our work should be of widespread value, particularly in the establishment of good testing techniques. Mr. Warwick then described the organization of the new administrative committee on simulated service testing and detailed some of the work already resulting, including the new committee on testing of building construction. Three extensive symposiums are being held at the Annual Meeting in Buffalo—one on fatigue, one on the testing of parts and assemblies, and the third on bearings.

In the field of ultimate consumer goods there is intensive interest in evaluating these products, and consequently a necessity of applying suitable test methods, many of which may be drawn from work involving engineering and industrial materials. He said that our activities would be based on sound engineering plans and practices, would proceed carefully, and would at all times be based on adequate technical preparation. The administrative committee which has been organized has been laying the groundwork for further establishment of specifications and tests for ultimate consumer goods and how they should be set up. He pointed out that several of the technical committees had already covered materials which were essentially of an ultimate consumer material, such as turkish toweling, soaps, etc. He concluded by discussing some administrative matters and then described the development of the new Headquarters building.



Left to right, extreme left, F. M. Harris, Pacific Gas and Electric Co.; J. R. Townsend, President, A.S.T.M.; Dozier Finley, Northern California District Chairman; Leo Berner, Chairman, San Francisco Section, A.W.S.; Executive Secretary C. L. Warwick; P. V. Garin, Secretary Northern California District, and in profile, lower left, M. C. Poulsen, District Vice-Chairman.

Northern California District Hears Officers at Joint Meeting

FOLLOWING the meeting with the Southern California District, President Townsend and Executive Secretary Warwick journeyed to San Francisco where a joint meeting had been arranged with the local section of the American Welding Society on Monday, March 25. Both men spoke at this meeting, Mr. Townsend again presenting his paper on Materials Engineering at Home and Abroad, which is published elsewhere in this BULLETIN. At this meeting there were about 100 engineers and technical men present, including a good representation from the A.W.S. San Francisco Section, whose officers Leo Berner, Joshua Hendy Iron Works, Chairman, and R. E. Labagh, Victor Equipment Co., Secretary, cooperated closely with the A.S.T.M. District officers, Dozier Finley, Paraffine Cos., Inc., Chairman, and P. V. Garin, Southern Pacific Co., Secretary. Since some notes on the topics covered by the speakers at this meeting have been given above in the account of the Southern California District meeting, this news account of the San Francisco meeting can be abbreviated with the conclusion that it was a very successful affair. The accompanying photograph was taken at the meeting.

New England District Being Organized

AT A meeting to be held in Boston at the Engineers Club on Monday, May 20, a New England District Committee is to be organized. Preliminary discussion of the desirability of such a move was held late last year with a number of the members in the Boston area and subsequently a questionnaire was sent to all members and committee people in New England. A great preponderance of those responding were much in favor of this move which would stimulate interest in the work of the Society and result in the other advantages which ensue from work sponsored by district committees.

The exact title of the District has not been selected, this decision being a matter for the new District Committee to discuss with the Administrative Committee on District Activities, nor have the exact boundaries been determined, but it is expected to encompass all of New England except the several counties of Connecticut that logically fall in the New York District. Further announcement will be made concerning these matters.

At the Boston meeting there is to

be an organization session of the District Committee followed by an informal dinner to which all members and committee members in New England and their friends have been invited. The meeting will be concluded with an informal session with talks by President John R. Townsend and Executive Secretary C. L. Warwick.

The meeting has been arranged under the temporary chairmanship of Past-President Herbert J. Ball, Lowell Textile Institute, who will preside at the sessions. C. H. Fellows, Detroit Edison Co., Chairman of the Administrative Committee on District Activities, will also be present.

The nucleus of the District Committee comprises about twelve leading A.S.T.M. members in the area, all of whom have participated in various phases of the Society's activities. Acceptances are now being received and the August BULLETIN will carry a list of the personnel, including the new officers who will be elected at the meeting on May 20.

Chicago Meeting on Simulated Service Testing of Materials and Assemblies

AS PART of a Chicago Production Conference arranged under the auspices of the Chicago Technical Societies' Council, the A.S.T.M. District there sponsored a most interesting and well-attended session on March 22 comprising three papers by leading authorities on aspects of the simulated service testing of materials and assemblies.

The program had been arranged by Program Chairman George E. Stryker, with the district officers, Messrs. J. F. Calef, J. J. Kanter, and J. de N. Macomb cooperating closely.

The titles of the addresses and speakers follow:

Some Applications of Simulated Service Testing on Non-Metallic Materials—Alan Frease, U. S. Forest Products Laboratory, Madison, Wis.

Correlation of Laboratory Testing with Service Performance—J. O. Almen, Head, Department of Mechanical Engineering I, Research Laboratory Div., General Motors Corp., Detroit, Mich.

Laboratory Testing of Consumers Goods—A. T. Chameroy, Manager of Merchandise Testing and Development Laboratory, Sears, Roebuck and Co., Chicago, Ill.

Two of these addresses were in the form of technical papers and the very interesting one by Mr. Chameroy on "Laboratory Testing of Consumer Goods" is published in this May BULLETIN. It will be of interest to almost every A.S.T.M. member regardless of his industrial activity. The second paper which it is probable will be included in the August BULLETIN or a subsequent issue is Mr. Frease's covering nonmetallic materials.

New York District Hears Three "Foreign" Travelers Discuss Their Observations

A MOST interesting and instructive meeting was held under the auspices of the New York District on May 2 when President John R. Townsend, Bell Telephone Labs., Inc., Dr. D. E. Douty, United States Testing Co., and W. L. White, Manhattan Rubber Div., Raybestos-Manhattan, Inc., spoke on their experiences and observations made in different theaters of war, in line with government-sponsored technical investigations. A Program Committee, headed by Dr. T. Smith Taylor, United States Testing Co., Inc., S. R. Doner, Manhattan Rubber Div., Raybestos-Manhattan, Inc., and H. J. Jaquith, Minot, Hooper and Co., arranged for the speakers. E. A. Snyder, Socony Vacuum Oil Co., handled the informal dinner at the Engineer's Club, prior to the meeting which was in the Engineering Societies' Building. The program follows:

TECHNICAL CHAIRMAN: Myron Park Davis, Chief Chemist and Metallurgist, Otis Elevator Co., N. Y., District Chairman.

Communications Materials and Systems in Europe—J. R. Townsend, Materials Engineer, Bell Telephone Labs., Inc., New York, N. Y.

Japan, Our Foster Nation—D. E. Douty, President, United States Testing Co., Hoboken, N. J.

Mechanical Rubber Goods, Reclaimed Rubber, Yarns, and Fabrics—W. L. White, Director of Research and Product Design, Raybestos-Manhattan, Inc., Manhattan Rubber Div., Passaic, N. J.

While Mr. Townsend was concerned with communications work he also had excellent opportunities for investigating materials in general. His group had reviewed a number of technical and materials problems before entering the foreign zone, and they concentrated on ways in which the Germans had attempted to solve some of the same problems we have. Obviously there were different solutions. Before the war the Germans had set up many underground stations for telephone and other communication connections. He was surprised to observe that only a small percentage of telephone manufacturing plants seemed to be making war goods; that the technical help was not too hard pressed; but noted the great amount of slave labor ranging from 10 to 80 per cent.

In most of their operations the Germans depended on skilled men who seemed to have had long apprenticeships and had excellent knowledge of the work. Consequently the amount of supervision was minimized, but there was a leaning toward elaborate design which did not expedite production. The German scientific workers seemed to be highly respected and well known in their communities. He mentioned a number of the interesting developments he had seen and studied, some of which are now being observed closely, or actually used in this country. Included are ceramic metal seals for vacuum tubes; artificial quartz; silver paste for welding condensor containers; and exceptionally well-made selenium rectifiers. They seemed to be short of mica, but substituted a product made by putting a slurry of titanium dioxide on a plastic base, which base was then burned.

Dr. Douty gave an interesting background of the complex development of the

Japanese people, their nation and government. A heterogeneous mixture had come together and achieved down through the centuries a remarkable homogeneity. The various characteristics of the races which came together may be partly responsible for their inherent virility. Until Perry, and events subsequent to his landing, there had been hardly any excursions from abroad into the island chain. He pointed out that they seem to retain racial characteristics with great tenacity, but are influenced rather quickly by heredity and environment. Dr. Douty mentioned the remarkable developments in approximately 70 years of their industrial activities, with a world-wide chain of banks, world-encircling shipping lanes which antedated even our own, and expressed his opinion that the most amazing situation of all was the way in which they could develop, in a relatively short space of some three-quarters of a century, the personnel to develop and man their enterprises. He concluded with a rather hopeful picture of the progress which will be made by the present Allied Nations Control and felt that the Japanese, as a whole, would cooperate very well with the policies and decisions of General MacArthur since they felt he was trying to be fair.

Dr. Douty pointed out that in contrast to the European destruction, the Japanese damage was almost entirely due to incendiary action. A great proportion of their urban centers and industries have been burned out. What the future may hold for production, was a subject for which time only has the answer.

Mr. White developed his thesis by comparing his extensive visit in 1936 when Hitler was about reaching the peak of his power and with the results of the subsequent years, with his studies of much of the same territory in 1945. He was curious about what improvements had been made in their synthetic rubber polymers, which development had been getting under way intensively in 1936; what they might have done with various fabrics, rayons, nylons, etc., since cotton was largely cut off; and also especially with the relative merits from the technical and production viewpoints of democratic government as against a dictatorship. He left no question in the minds of those present that while the Germans felt they had to have a dictatorship because, as they put it, they did not have the great plenty to waste, such as we had in this country, or as had the British with their empire, their dictatorship developed great inefficiencies instead of the converse, for which they had planned. Mandates on how to produce mechanical rubber goods, and the materials to be used seemed to come from the synthetics laboratories which were part of the I. G. Farben colossal technical center. No German technologist or production executivew as going to risk banishment or Gestapo action by disputing what had been recommended no matter how inefficient. Mr. White contrasted with this the general picture of intense cooperation in this country where different manufacturers pooled technical data and assumed production of sizes and kinds of mechanical rubber goods which they could turn out in greatest proportion. Mr. White said this leaves no question on the best final pay-off practice. He pointed out that one of the reasons for German concentration on synthetic rubbers came because of their feeling that the primary reason for having lost World War I had been due to material shortages. Even though they had some good synthetics, they did not seem to realize the importance of concentrating production on one or two of the better types, but had different compounds for a whole variety of purposes. It was somewhat the same story stressed by Mr. Townsend in his earlier talks, that the Germans seemed to have technical, but not production, know-how.

All of those present, about 135, agreed the program had been most worth while.

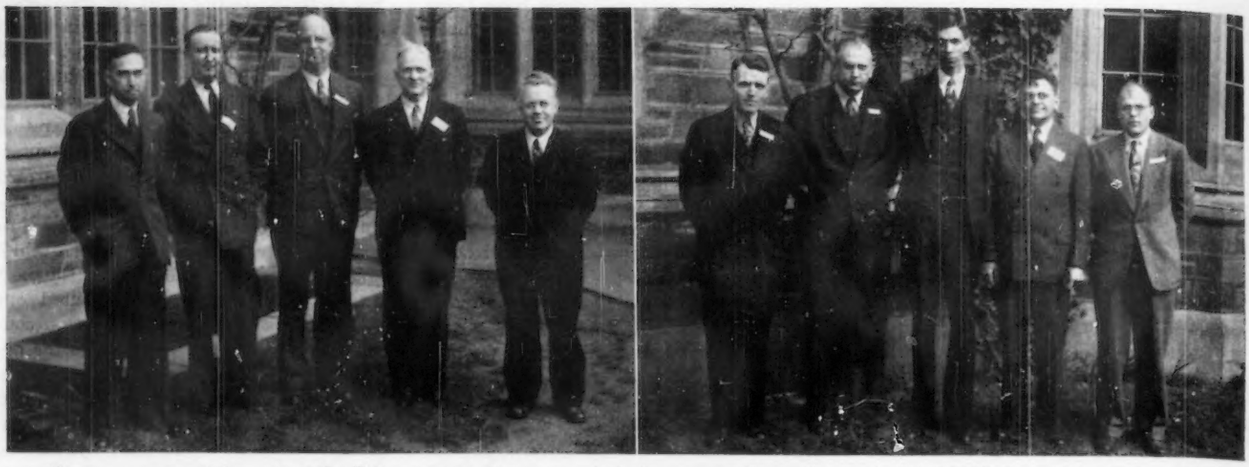
A.S.T.M. Committee Meeting at Princeton on Polarographic Analysis

An interesting discussion of polarographic analysis was presented at the special meeting of Division D on General Analytical Methods, of Committee E-3 on Chemical Analysis of Metals, held in the auditorium of the Frick Chemical Laboratory at Princeton University on Saturday, April 6. About fifty were present at the meeting, the purpose of which was the discussion of the application of polarographic analysis to the methods of chemical analysis of metals being developed by Committee E-3. Dr. S. E. Q. Ashley, General Electric Co. (Pittsfield), Chairman of Division D, opened the meeting and introduced Dr. Hugh S. Taylor, Dean of the Graduate School and Chairman of the Department of Chemistry of Princeton University, who welcomed those present.

Dr. J. J. Lingane of Harvard University was the first speaker. He discussed the history of the development of polarographic methods of analysis and the basic principles involved. He also discussed the various types of apparatus for polarographic analysis, both those which may be made up by the individual for his own use and those available commercially, with a candid discussion of the principal merits and disadvantages of each type. He recommended the use of standardized diffusion constants. Dr. Lingane concluded by outlining and discussing the more important factors in actual polarographic analysis and described a method for determining lead, tin, nickel, and zinc in copper base alloys.

Dr. Furman of Princeton University described the work on polarographic analysis that has been done there. He pointed out that the work at Princeton had emphasized the utility of the polarographic methods for trace analysis; for example, where the purity of reagents or other pure chemicals is to be determined. He also discussed the value of a study of best methods of separations, and of solvents or "supporting electrolytes," for improving polarographic methods of analysis.

At this point the morning session of the meeting was opened to general discussion. It was mentioned that polarographic methods can be valuable for qualitative determination of the presence of elements as well as for quantitative determinations of the exact amount present. The point was also stressed that polarographic analysis is an "art" requiring special training beyond that of an average analyst for the development of new procedures, the application of existing procedures to a special problem, and the interpretation of results. However, for routine analytical work, it was stated that polarographic analysis is rapid and requires only moderate skill. Since some special training in the use of polarographic apparatus is considered desirable, the present trend in the chemistry departments of universities toward training students in "instrumental analysis" may be very helpful in providing trained personnel who can and will greatly increase the utility of polarographic analysis in practical applications. The same inertia now existing in adopting polarographic methods of analysis in industrial



Above are some of the men at the Princeton meeting, several of whom are active in the work of A.S.T.M. Committee E-3 on Chemical Analysis of Metals. From left to right, D. R. Evans, Chief Chemist, Western Electric Co., Inc., Chairman of Div. B on Non-ferrous Metals; Arba Thomas, The American Rolling Mill Co., Chairman of Div. A on Ferrous Metals; J. W. Stillman, E. I. du Pont de Nemours and Co., Inc., Secretary of Committee E-3; W. C. Bowden, Jr., Chief Chemist, Ledoux and Co., Inc., Chairman of Div. C on Sampling; C. L. Luke (very active in the work of Committee E-3, notably in Divs. B and D), Bell Telephone Labs., Inc.; Dr. J. J. Lingane, Professor in Dept. of Chemistry, Harvard University; Dr. N. H. Furman, Professor in Dept. of Chemistry, Princeton University; Dr. A. H. Bushey, Asst. Chief, Analytical Div., Aluminum Research Labs., The Aluminum Company of America; Dr. S. E. Q. Ashley, Pittsfield Works, General Electric Corp., Chairman of Div. D on General Analytical Methods of Committee E-3; and K. G. Stone, Princeton University.

laboratories formerly existed in spectroscopy but has largely been overcome by education. Emphasis was placed on the value of study by graduate students along new lines such as this in the development of practical applications. As an example of a special application, there was described the possibility of using a rotating platinum electrode for a continuous recording setup such as for the continuous determination of oxygen in a water line.

The afternoon session was opened by a brief business meeting of Division D at which the minutes of the previous meeting in Pittsburgh were approved.

Mr. Stone of Princeton University discussed the use of organic analytical reagents in connection with polarographic methods, particularly in amperometric titrations.

Dr. Bushey, The Aluminum Company of America, then spoke on the practical value of polarographic analysis in an industrial laboratory. He stated that polarographic methods have been found most useful by his company in the solution of special problems rather than in routine control. Polarographic methods have proved useful in avoiding interferences troublesome in other analytical procedures. The methods have been found to be suited for the determination of metallic impurities in organic matter, the successful determination of several elements in a single solution, and the determination of true values in a standard for other types of analysis. Discovery of the best method of complexing the elements to be determined can be said to be the key to successful polarographic analysis.

Dr. Bushey compared polarographic analysis with photometry. Polarographic methods are suitable for use with reducible or oxidizable substances, while colorimetry makes use of color-forming complexes. For very low concentrations of an element, photometric analysis may be more sensitive, while for somewhat higher concentrations (still moderately low), polarographic determinations are considered more precise. For high concentrations of an element, the conventional gravimetric and volumetric methods are still employed. Dr. Bushey mentioned that for industrial work automatic recording types of polarographic apparatus have many advantages.

Fire Tests of Materials and Construction

COMMITTEE C-5 on Fire Tests of Materials and Construction held a meeting in Washington, D. C., on March 21, 1946, which was preceded by meetings of several subcommittees. Prior thereto, considerable progress had been made by correspondence and meetings among members of groups concerned with given projects. The following relates to some of the matters that were considered at the meeting.

Modern methods of impregnating wood under pressure with solutions of fire-retarding chemicals has made necessary development of methods for evaluating the effect produced. As the result of tests sponsored by the Committee, a tentative procedure (C 160) was published in 1941 based on a "crib" test adapted from one that had been in use in approvals of treated wood by New York City. With minor revisions, this method is now proposed by the committee for adoption as standard. A method is also proposed involving the use of a test developed by the U. S. Forest Products Laboratory, according to which a single long specimen is burned under controlled conditions in a draft tube, instead of firing a "crib" built up of 24 shorter pieces. By both methods the performance is gaged by the loss in weight after burning has ceased following exposure to a gas flame for 3 or 4 min.

Amendments to present standard C 19 – 41, Fire Tests of Building Construction and Materials, were acted on, concerned with corrections to be applied to results of fire tests

to compensate for variations of the furnace exposure from that prescribed, fire tests of steel columns without application of load, and fire tests of ceiling constructions.

Some variation from the prescribed fire exposure is inevitable in fire tests and the results are more representative if reported with an applicable correction. The method of correction is based on the theory of heat flow through solid materials and has been verified experimentally to the extent the limited applicable data afford a basis.

Since there are few facilities available for conducting fire tests of columns under load, a method was developed for determining the limit of performance of structural steel columns by the temperatures attained in the column steel. For this material the relation between strength and temperature has been quite well established in full-scale fire tests of columns as well as in tests of smaller specimens.

The degree of fire resistance of ceilings is important on account of possibility of spread of fire through the spaces above them. Such spaces, as in attics, often extend undivided over the whole or greater portion of a building. The criteria of performance, according to the proposed method, are based on structural integrity of the ceiling in preventing the passage of flame and hot gases, and the protection given constructions in contact with or adjacent to the upper face of the ceiling.

Committee C-14 Represents Glass Division of American Ceramic Society

COMMITTEE C-14 on Glass and Glass Products met in a dual capacity at the Hotel Statler, Buffalo, N. Y., on May 1, during the Forty-eighth Annual Meeting of the American Ceramic Society. Since the Committee is officially designated as representing the A.C.S. on standards for glass and glass products, Chairman Navias included this meeting in the formal program of the sessions of the Glass Division of the A.C.S., of which he also acted as Chairman. A fine tribute was paid to the importance and need of the A.S.T.M. by such organizations as the A.C.S. especially as a bulwark and coordinator in establishing recognition of standards both nationally and internationally.

Eight of nine subcommittees submitted written reports, indicating a healthy upsurge in the resumption of activities following the war period. Current activities include a program of cooperative tests to compare conditions of glass durability tests under U. S. Pharmaceutical and A.S.T.M. methods; drafting of tentative methods of sampling and testing cellular non-load bearing glass blocks and consideration of revisions of existing standards on glass containers. The completion of the ring section methods of examining glass containers may be delayed as long as two years due to inability to procure suitable equipment.

Poles and Determination of Moisture Content Important Problems of Committee D-7 on Wood

COMMITTEE D-7 on Wood held its first meeting of the year at the Palmer House in Chicago on March 12 with seventeen members and six guests in attendance. The two most significant developments at the meeting were the action taken to establish a new Subcommittee on Wood Poles (Subcommittee VII) and the report on development of a new method for the determination of the moisture content of wood treated with fire-retardant chemicals.

The tremendous current demand for wood poles by the Rural Electrification Administration and various utilities involves consideration of specifications for the material, preservative treatment and treating methods, as well as pole design stresses for various species of wood.

The new method for ascertaining moisture content will answer a long-felt need for a quick method for such a determination. Existing moisture meters, although usually reliable for determining moisture content of untreated wood within certain moisture limits, are not accurate for use with wood treated with fire-retardant chemicals.

All standards under the jurisdiction of the committee were reviewed and recommendations made on a considerable number for changes and revisions, with these standards being referred to the respective subcommittees.

Other developments and progress made by the several subcommittees reporting are noted as follows:

Conversion of present grades of structural wood members into cutting grades so as to insure each part of a timber cut in two having original grade.

Extensive research in progress for data on laminated timber specifications.

Structural plywood specifications receiving first consideration.

Wood paving block specifications being developed for interior use.

Additional specifications on methods of preservative treatment expected during coming year.

Newer accepted materials for timber preserving and preservatives not already covered will receive attention in addition to revision of existing specifications.

Development of a secondary standard procedure for testing and evaluating properties of second-growth material and smaller species not attaining commercial size.

Nomenclature and definitions being revised due to many objections to tree-name terminology established by U. S. Dept. of Agriculture.

Best method of selecting samples is still the most serious problem in conduction of fire tests.

Chairman Hermann von Schrenk, St. Louis, Mo., and Secretary L. J. Markwardt, Madison, Wis., arranged and conducted the meeting.

Necessity for Adequate Shipping Containers Influences Committee D-10 Work

CHAIRMAN Edward Dahill, in opening the meeting of Committee D-10 on Shipping Containers, emphasized the importance of continued research in and attention to producing satisfactory shipping containers as shown by the lessons learned at great expense during the war. Coordinating the time and place of the meeting with that of the Packaging Conference and Exposition of the American Management Association, the committee and five of its six subcommittees met at Atlantic City on April 4 and 5. An international tone and interest in the work of the committee were shown by the presence of two visitors from The Netherlands and the receipt of communications from Australia, New Zealand, and India.

Subcommittee I on Definition of Terms reported the latest draft of definitions submitted for ballot was again being redrafted as a result of the many additions, changes and criticisms that had been submitted. Much progress has been made since the last meeting in standardizing methods of tests, as reported by Subcommittee II on Methods of Testing. Out of five proposed tentative methods submitted, three have now been accepted, namely, drop test, compression test, and drum test for shipping containers. The incline impact test for shipping containers is being submitted to the committee for letter ballot. Additional research data have been found necessary before submission of a proposed vibration test method can be made.

A very hard working subcommittee was in evidence as shown by the accomplishments of Subcommittee III on Moisture and Water Vapor Resistance, which presented drafts on tentative methods covering the spray test, water vapor permeability test, and submersion test on shipping containers.

Subcommittee IV on Performance Standards outlined a program based on scope and timing, the former to be limited to those test methods now in use, or to be adopted, and the latter based on the test methods after a period of trial. Interior packing will be studied by Subcommittee VI on Interior Packing through the organization of sections within the subcommittee to cover bibliography, definition of terms, and listing of all available interior packing materials, performance standards and testing procedures.

Testing Shipping Containers and Materials

ONE of the interesting sessions at the Packaging Conference held under the auspices of the Packaging Division of the American Management Association at its meetings in Atlantic City in April involved an extensive panel discussion on the testing of shipping containers and materials from which they are fabricated. Several of the speakers are very active in A.S.T.M. work and take a leading part in the activities of Committee D-10 on Shipping Containers. Included in this group were Messrs. R. L. Beach, T. A. Carlson, Edward Dahill, T. J. Gross, Robert C. McKee, and Earl R. Stivers. The session was arranged by another long-time A.S.T.M. member, Albert W. Luhrs, who is Vice-President in Charge of the A.M.A. Packaging Division and who presided at the meeting. The program was as follows:

Beach and Mullen—R. L. Beach, General Electric Company, Schenectady, N. Y.

Compression—T. J. Gross, President, Container Testing Laboratories, Inc., New York, N. Y.

Conbur—Edward Dahill, Chief Engineer Freight Loading and Container Bureau, Association of American Railroads, Chicago, Ill.

Cushion—J. H. Goss, Engineer, Works Laboratory, General Electric Co., West Lynn, Mass.

Drop—A. L. Green, Special Representative, Freight Claims Division, Association of American Railroads, Chicago, Ill.

Drum—T. A. Carlson, Chief, Division of Matériel Containers, Forest Products Laboratory, Madison, Wis.

Vibration—Earl R. Stivers, Director of Research, Package Research Laboratory, Rockaway, N. J.

Correlating Laboratory Tests with Actual Performance—Robert C. McKee, Chief, Container Section, Institute of Paper Chemistry, Appleton, Wis.

Since many A.S.T.M. members are concerned in this field a résumé of the remarks follows—it is expected that the papers and the ensuing questions and answers will be issued by the A.M.A. as a separate handbook.

Beach and Mullen:

In opening the session Mr. Beach, who is Vice-Chairman of A.S.T.M. Committee D-10 and Chairman of its Subcommittee on Fiberboard and Fiberboard Containers functioning in Committee D-6, possibly sounded the general keynote of the session which was that despite the great advantage which would ensue from the search for a universal tester to give a complete evaluation of containers, none had been agreed on, and such a development was probably a distinct impossibility; nevertheless there are a number of tests coming into widespread use which will indicate in some degree the performance characteristics of shipping containers and materials, and test adequately the different characteristics. He described the so-called General Electric or Beach Puncture Tester which is covered in A.S.T.M. Methods D 781, and also commented on the Mullen or Bursting Test, Methods D 774. Originally the puncture tester which indicates the resistance of the material to puncturing was calibrated in inch-pounds but now a more practical calibration is used, namely, the inch-ounces per inch of tear. This test measures the resistance of fiberboard to tear and bending or, in other words, strength of fiber and stiffness of board. As yet there is no correlation with other tests and certainly not with the Mullen test. He stressed the value of

measuring the materials after fabrication into the container as against the materials tested separately, citing the value of 250 on the tester for materials made up in a container compared with the value of 95 when tested separately.

Compression:

Mr. Gross pointed out, too, that there is increasing interest in a satisfactory performance test of the entire package (if one is ever agreed on it will have to be under exaggerated use conditions). He advocated the use of the compression test (A.S.T.M. Methods D 642) which gives a measure of the rigidity of the container or its resistance to external forces, both for static and dynamic loads, but stressed the necessity of knowing not only the load withstood but the deflection involved. Shape, size, and style of containers affected the interpretation of the test markedly. Humidity conditions must always be specified as results vary widely under different moisture contents of the fiberboard. The compressive test shows that quality of fabrication is the most important factor in resisting compressive forces, and the test gives a good gage of fabricating efficiency. Some of the deleterious influences on container efficiency, particularly fiberboards, involve excessive printing pressures which have been shown to destroy up to 30 per cent of the container's effectiveness, poor adhesion, finger lines, high and low corrugations and similar irregularities of manufacture.

Conbur Test:

Mr. Dahill in covering the Conbur test, which is an inclined impact test named after the Container Bureau of the American Association of Railroads, pointed out that it is a simple, easily handled test, can be set up in any laboratory without much trouble, and has the distinct advantage of evaluating damage caused by impact. To function effectively the inclined plane should be on a 10-deg. angle with the track straight and smooth; wheels on the dolly used to hold the container must be free-running and the backstop rigid and unyielding. Essentially the action is a delayed drop impact and any kind of a container can be tested on it. He pointed out that a long length of track is not necessary. Height of vertical drop is the most important factor. (This test is being studied in A.S.T.M. Committee D-10 and will be a part of its 1946 report.)

Cushioning Test:

There was much interest in a new electronic instrument developed by General Electric Co. which evaluated the cushioning material used in a container in terms of G-units. This is devised to record the deceleration afforded by the cushioning, a simple example according to the speaker being a measurement of the effectiveness of one's knees in bending, for example in an elevator which stops suddenly. With this instrument quick control can be set up to insure the desired cushioning effect in a specific container.

Drop Test:

In his discussion and demonstration, Mr. Green pointed out that the drop test (A.S.T.M. Methods D 775) was a relatively inexpensive one which has been widely used in both commercial and government laboratories. It is limited to moderate weight packages and is especially good in the evaluation of inner packaging materials. He pointed out that in one recent year the American railroads were called upon to pay claim for over eight million dollars' worth of concealed damage alone, and that in 1944, 57 per cent of all claims paid was for packaged freight.

Drum Test:

The drum test recently covered in a revised A.S.T.M. Standard D 867 – 46 T, in Mr. Carlson's opinion, is the most practical equipment either in the 7 or 14-ft. sizes for evaluating the resistance of a container to rough handling. The slow speed at which the container revolves permits a gradual development of container weaknesses and this is desirable. Baffles in the drum are arranged so that there will not be a regular cycle of the same hazard, and while the test is not a precise one, with careful operators and equipment in good shape, results over the years have proved to be extremely valuable. He pointed out that containers particularly are not precision built and there are many variations so that in this test and others we must be sure to include a sufficient number of samples—in his opinion at least five and preferably more. There are at least 35 of the 7-ft. drums in constant operation in evaluating containers and at least 12 of the 14-ft. size that he knows of.

Vibration Test:

Mr. Stivers pointed out that the vibration test made on an oscillating platform was an excellent method for evaluating the continuing effectiveness of container and interior packaging protection against periodic repetition of stresses and strains. The test is very valuable in providing comparative data. It is not possible, he said, to state that any amplitude or any period of vibration would be equivalent to a definite number of railroad miles. Much work has been done for the armed services and one branch is now proposing as a test an excursion of 0.025 in. with cycles ranging from 16 to 67 per second. Several tables now in use, use cycles ranging from 4 to 9 and excursions from $\frac{1}{4}$ to 1 in. In one comprehensive series of tests on a large variety of case liners, the results duplicated experience in actual shipments of material to the war theaters. In packing for glass insulators, the results quickly revealed the inadequacy of the interior separators. In tests on egg cases, a marked difference was evident from various packing methods. In tests on belted ammunition, the same failures occurred as were reported from the war fronts.

Correlation:

Mr. McKee confined his remarks largely to fiberboard products and outlined a very extensive series of investigations to be undertaken by the Container Section of the Institute of Paper Chemistry. This subject has been discussed in A.S.T.M. Committee D-10 and this committee also has as part of its long-range plans the institution of work to determine whether it is possible within reasonable limits to establish some correlation of results of one test with another.

This Program is Subject to Change

All time indicated is Eastern Daylight Saving Time

Provisional Program

FORTY-NINTH ANNUAL MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

BUFFALO, N. Y. **HOTEL STATLER** **JUNE 24 TO 28, 1946**

	Morning	*Afternoon*	*Evening*
Monday, June 24	Registration Committee Meetings	Committee Meetings	*1st* Symposium on Bearings
Tuesday, June 25	*2nd* Symposium on Fatigue *3rd* Symposium on Spectroscopic Light Sources	*4th* Symposium on Fatigue (*Cont.*) *5th* Symposium on Spectroscopic Light Sources (*Cont.*) *6th* Symposium on Oil Procurement Practices	*7th* Technical Papers on General Testing Methods
Wednesday, June 26	*8th* Symposium on Testing of Parts and Assemblies *9th* Technical Papers on Cement and Concrete	*10th* Symposium on Testing of Parts and Assemblies (*Cont.*) *11th* Presentation of Report of Committee D-2. Symposium on Oil Procurement Practices (*Cont.*) 4:30 p.m. *12th* Marburg Lecture, Dudley Medal	Annual Dinner President's Address, Guest Speaker, Awards
Thursday, June 27	*13th* Session on Effect of Temperature on the Properties of Metals—Materials for Gas Turbines *14th* Symposium on pH Measurements	*15th* Symposium on pH Measurements (*Cont.*) *16th* Presentation of Reports of Committees A-1 to A-10, D-1, E-1 to E-7	*17th* Session on Effect of Temperature on the Properties of Metals—General (*Cont.*) *18th* Symposium on Atmospheric Weathering of Corrosion-Resistant Steels *19th* Symposium on Freezing-and-Thawing Tests of Concrete
Friday, June 28	*20th* Presentation of Reports of Committees C-1 to C-18 *21st* Presentation of Reports of Committees B-1 to B-9, D-3, D-5 to D-7, D-9 to D-17, D-19, D-20	*22nd* Technical Papers on Plastics and Wood *23rd* Technical Papers on Non-Ferrous Metals *24th* Bituminous Materials, Reports of Committees D-4, D-8, D-18	

Monday, June 24 8 p.m. First Session

Symposium on Bearings

Life Testing of Plain Bearings for Automotive Engines. E. T. Johnson, Chrysler Corp.

This paper describes a machine which is in fairly general use for the testing of sleeve-type engine bearings. It combines conditions of possible seizure, fatigue, and, if desired, corrosion.

The chief stresses applied to the bearings are compressive in nature and exceed maximum engine loading by from 80 to 110 per cent, depending on model of bearing.

This test is valuable for quality control, preliminary check of new types of bearings, and comparison of the results of changes in technique of producing bearings.

Fatigue Testing Machines for Ball and Roller Bearings. Thomas Barish, Consulting Engineer.

The major problems involved in fatigue testing machines for ball and roller bearings are:

1. Maintaining alignment under the very heavy radial and thrust loads used,
2. Frequent disassembly,
3. Application and control of heavy loads,
4. Lubrication, and
5. Early detection of failure.

The paper shows how many of the currently used machines meet these problems.

Metallographic Observations of Ball Bearing Fatigue Phenomena. A. B. Jones, New Departure Division of General Motors Corp.

This paper describes the results of many years of observation of ball bearings run to fatigue failure under laboratory test conditions by New Departure. As a result of metallurgical investigation of test bearings, certain structural changes in the material which precede fatigue failure have been noted which bear a definite relation to bearing life and load. Micrographs showing these structural changes are presented, together with an explanation of the cause of the phenomena.

Fatigue Testing of Roller Bearings. H. R. Gibbons, Hyatt Bearing Division of General Motors Corp.

In the early 1900's, fatigue knowledge of roller bearings was equal to that of plain bearings. Accompanying the development of fatigue data, testing equipment underwent an interesting evolution. The progressive steps in the development of fatigue life ratings are outlined and factors affecting these ratings are discussed. Fatigue life dispersion, shown graphically, is compared with human life expectancy. Bearing life is dependent on raw material properties, heat treatment and quality of workmanship. A typical *S-N* curve is shown and the probability of an endurance limit suggested.

Testing of Bearings Under Controlled Load. J. M. Frankland, Chance Vought Aircraft Division of United Aircraft Corp.

An apparatus is described which permits the testing of plain and antifriction bearings under conditions simulating a planet gear bearing. The test bearing is rotated off center and can be subjected to independently adjustable radial and tangential loads. A limited range of speed ratios between test bearing and main shaft can be obtained. The effects of load, speed, and lubrication on the breakdown of bearings can be conveniently studied under conditions closely simulating an actual installation.

Tuesday, June 25 9:30 a.m. Second Session

Held Simultaneously with the Third Session

Symposium on Fatigue

Fatigue Tests of Rail Steel Under Compressive Stress. R. S. Jensen and H. F. Moore, University of Illinois.

Fatigue tests were made on T-shaped specimens cut from a rail web under cycles of stress varying from compressive stress to tensile stress 20 per cent as great as the compressive stresses. The testing machine used was a vibratory machine.

The fractures for such specimens started on the compression side of the specimen and the compressive stresses were about 78 per cent higher than the stresses in specimens subjected to cycles of completely reversed bending stress. Under completely reversed stress the fractures started on the tension side of the specimen.

Reduced stresses at fracture resulted in tests of specimens with stamped letters at the critical section on the compression side.

Although shot peening sets up longitudinal compressive stress in the unstamped specimens the fatigue strength of shot-peened specimens was approximately 32 per cent greater than for specimens in which the surface of the compression side was left in the as-rolled condition.

A Study of the Damaging Effect of Fatigue Stressing on X4130 Steel. J. A. Bennett, National Bureau of Standards.

The damaging effect of fatigue stressing above the endurance limit was investigated with notched specimens of X4130 steel. The damage was measured by the decrease in endurance at another stress, and the results showed that the apparent rate of damage depends on the stress history.

In another group of tests, in which smooth specimens were used, a method of expressing damage independent of stress was developed. This permitted the direct addition of damage occurring at different stresses. The reliability of the method was checked by testing specimens after fatigue loading at two or more different stresses.

Fatigue Properties of Several Alloy Steels as a Function of Hardness. Henry Hermann ZurBurg, Chrysler Corp.

Fatigue data have been obtained for S.A.E. 4063, S.A.E. 4140, S.A.E. 4340, and S.A.E. 2340 in the smooth and notched condition for hardnesses ranging from 20 to 65 Rockwell "C." The R. R. Moore type specimen was used for all tests. The theoretical stress concentration factors for the three V notches are 2.55, 2.29, and 1.86 and a factor of 1.41 for the semicircular notch. The various hardnesses were obtained in each case by tempering a fully quenched martensitic structure.

The smooth bar results show that the relationship between endurance limit and hardness depends on the carbon analyses of the steel and is independent of the alloy content for the materials tested. The curves show peak endurance limit values of 107,000 psi. at 45 Rockwell "C" for the 0.40 carbon steels and 130,000 psi. at 55 Rockwell "C" for the 0.65 carbon material.

Notch sensitivity has been calculated (the value q as defined by Peterson) for three of the materials. The S.A.E. 2340 has a constant q value over the hardness range of 25 to 50 Rockwell "C." The S.A.E. 4140 and S.A.E. 4063 steels have a maximum value for q at low hardnesses (30 to 35 Rockwell "C") and a minimum value at 50 to 55 Rockwell "C."

Fatigue of Wood and Glued Wood Constructions. W. C. Lewis, Forest Products Laboratory.

An understanding of the fatigue behavior of wood and glued wood constructions has required the development of proper testing machines and testing procedures. Some of the techniques and test methods have been perfected, and a significant number of tests have been made in bending, tension parallel to the grain, and shear, on specimens of wood, plywood, and wood with glued joints. Tests to date indicate that failures of wood specimens in fatigue have exactly the same appearance as those of corresponding specimens tested statically and that the *S-N* curves are similar in appearance to those for non-ferrous metals.

(Symposium continued in Fourth Session)

Tuesday, June 25 9:30 a.m. Third Session

Held Simultaneously with the Second Session

Symposium on Spectroscopic Light Sources

The Symposium on Spectroscopic Light Sources, sponsored by Committee E-2 on Spectrographic Analysis, is being held at the Third and Fifth Sessions of the Annual Meeting. The number of formal papers has been kept to four to provide ample time for discussion. The following men have been invited to prepare discussion on various phases of the subject:

R. H. Bell, Lucius Pitkin, Inc.
Wendell R. Koch, U. S. Army Air Corps.
C. J. Neuhaus, International Nickel Co.
E. K. Jaycox, Bell Telephone Labs., Inc.
R. D. McLellen, American Smelting & Refining Co.
Daniel Norman, New England Spectrochemical Labs.
H. S. Read, Westfield, N. J.
G. A. Perley, Leeds & Northrup Co.
J. R. Churchill, Aluminum Company of America
M. F. Hasler, Applied Research Laboratories
J. L. Saunderson, Dow Chemical Co.
A. M. Sampson, Campbell, Wyant & Cannon Foundry Corp.
J. O. Jarrell, Jarrell-Ash Co.
P. R. Irish, Bethlehem Steel Co.
L. W. Strock, Saratoga Springs Foundation

The Present Status of Excitation in Spectrographic Analysis. B. F. Scribner, National Bureau of Standards.

The development of the present modes of excitation to meet problems of excitation for spectrographic analysis are reviewed and the available excitation sources are discussed in the light of present-day analytical requirements. The sources include flames, continuous and discontinuous arcs, simple and controlled sparks, and the hollow-cathode discharge. It will be shown that, with certain electrical discharges, the forms of electrodes produce effects which must be considered in applications to spectrographic analysis. These effects are critical in the examination of nonhomogeneous materials or of samples containing constituents having widely different volatilities.

A Study of the Controlled Spectrographic Spark Source. J. H. Enns and R. A. Wolfe, University of Michigan.

Two controlled spark sources (synchronous and air interrupter type) have been studied with the object of obtaining optimum stability. The electrical circuit elements, including spark gap resistance, are analyzed. The energy input into successive sparks is carefully controlled. By means of a direct pickup (electron-multiplier) and the oscilloscope, instantaneous records are obtained to show the fluctuations in spectral line intensity as generated by successive sparks. Instantaneous records of two spectral lines, showing the ratio fluctuations, are similarly obtained.

(Symposium continued in Fifth Session)

Tuesday, June 25 2 p.m. Fourth Session

Held Simultaneously with Fifth and Sixth Sessions

Symposium on Fatigue (Continued)

Fatigue Tests on Some Additional Copper Alloys. Alton R. Anderson, Emery F. Swan, and Earl W. Palmer, American Brass Co.

A previous paper (A.S.T.M. *Proceedings*, Vol. 41) from this laboratory presented correlated endurance and tension test results for a number of hard-drawn copper-base alloys. The present paper includes similar data on several other commercially important copper-base alloys, in one or more hard-drawn tempers, and also data on some of the original alloys in the annealed condition. The effects of various amounts of cold work on the endurance behavior of several copper-base alloys is indicated and, in addition, the factor of grain size is shown to be of great importance. Both the grain size prior to the final drawing of hard-drawn alloys, and the final grain size of annealed materials, are shown to affect markedly the endurance behavior.

The Fatigue Properties of Beryllium Copper Strip and Their Relation to Other Physical Properties. G. R. Gohn and S. M. Arnold, Bell Telephone Laboratories, Inc.

Data on the fatigue strength and other physical properties of beryllium-copper strip are given for a number of commercial and experimental binary and ternary alloys. The properties of alloys of current manufacture are compared with those obtained on alloys tested at various times since 1936. The results of several different heat treatments and of over- and under-aging are described as well as the effects of a number of surface treatments. Curves illustrating the response of the alloys to various heat treatments are plotted in addition to the *S-N* fatigue curves.

The Fatigue Strength of Some Magnesium Sheet Alloys. L. R. Jackson and H. J. Grover, Battelle Memorial Institute.

One of the projects undertaken by the War Metallurgy Division of the N.D.R.C. during the war was the evaluation of magnesium sheet alloys as possible materials for the construction of aircraft.

This paper contains data on the direct-stress fatigue strength, and notch sensitivity under repeated stress of alloys of the J-h, J-a, M-h, M-a, FS-h, and FS-a types.

Properties of Several Plastics and an Aluminum Alloy as Obtained from Tests on Four Different Types of Fatigue Machines. William N. Findley and Robert L. Sutherland, University of Illinois.

The results of fatigue tests of two thermoplastics (cellulose acetate and polystyrene), three laminated plastics (paper, canvas, and fiberglas), and one aluminum alloy (25S-T) are reported. Four different types of fatigue machines were used to test most of the above materials. The fatigue machines were: rotating cantilever beam, constant amplitude of deflection, and constant amplitude of force, all of which tested specimens in bending; and a constant amplitude of deflection machine which tested specimens in direct tension and compression.

The results obtained from the four machines are compared for each material and the differences are analyzed. The analysis includes studies of the temperature developed in the different materials as a result of hysteresis damping, and the load-deflection characteristics of the materials under repeated loading.

The Notch Sensitivity in Fatigue Loading of Some Magnesium-Base and Aluminum-Base Alloys. George H. Found, The Dow Chemical Co.

Discusses fatigue tests of the rotating beam, axial loading, and plate bending types which were performed on a number of commercial magnesium- and aluminum-base alloys. The results are presented, but they are not believed to be directly applicable for quantitative design purposes. They are used, however, to draw the general conclusion that designing in magnesium requires added care where fatigue stresses under conditions of high stress concentration, short life, or elevated temperature are involved.

Tuesday, June 25 2 p.m. Fifth Session

Held Simultaneously with Fourth and Sixth Sessions

Symposium on Spectroscopic Light Sources (Continued)

Some Properties of Gas Discharges Used as Spectral Sources. R. C. Mason, Westinghouse Research Laboratories.

The experimental bases for the present knowledge of d-c. and low and high frequency a-c. arcs at atmospheric pressure are presented. The outstanding characteristic is the high gas temperature of several thousand degrees. From the external current-voltage relations of these discharges, and from what is known of their internal properties, the departures from true thermal equilibrium which occur are predicted. Some applications to spectral analysis and the effect of the external circuit are given.

Short Period Behavior of Spectroscopic Light Sources. G. H. Dieke, The Johns Hopkins University.

For spectrochemical applications the stability of a light source over a time interval of several seconds or minutes is important. Short period random fluctuations are averaged out. However, the causes for stability or instability usually are determined by the behavior during very short time intervals. Short interval studies of the light source are also necessary to explore and understand the often very complex fundamental processes occurring in the light source. These can often be studied much more readily in gas discharges at reduced pressures than in the usual arcs and sparks. Sensitive phototubes in combination with a cathode-ray oscillograph make it possible to study the behavior of light sources in time intervals as short as a millionth of a second or less. The results in gas discharges, arcs, and sparks are discussed.

Tuesday, June 25 2 p.m. Sixth Session

Held Simultaneously with the Fourth and Fifth Sessions

Symposium on Oil Procurement Practices

This symposium, sponsored by Technical Committee B of Committee D-2, will be held in two sessions, the second session being at 2 p.m. on Wednesday, June 26, 1946.

Oil procurement practices as used by various industrial concerns vary in complexity from very simple cases, where "viscosity" and "petroleum origin" are the only requirements, to very complex ones incorporating laboratory tests which take a year to complete and field trials as extensive as twelve months before the products under consideration can be evaluated. Such wide variations in procurement practices are to be expected when it is realized that the oils are used to lubricate simple line shafting, in one case and delicate precision machines, in the second.

It is natural for consumers to ask for simple all-inclusive specifications for use in the purchase of lubricants. Such specifications would relieve them of considerable worry attendant to the selection of satisfactory products. Experience has shown that the difficulties encountered in such specifications except in the simplest of cases are not easily surmountable because of the lack of correlation between laboratory test conditions and those encountered in setting up field service. Realizing that complete purchase specifications for oils could not generally be available for many years the oil and consumer interests cooperatively developed oil procurement practices which have made it possible for the ultimate consumer to select the best products for a given job. The practices of several companies will be described by the authors participating in the Symposium.

Introduction. T. A. Boyd, General Motors Corp.

Oil Procurement Practices in Industry:

C. Dantsizen, General Electric Co.
C. L. Pope, Eastman Kodak Co.
J. T. Hendren, Pan American Airways, Inc.

(Symposium continued in Eleventh Session)

Tuesday, June 25 8 p.m. Seventh Session

Technical Papers on Methods of Testing

An Automotive Tire Fatigue Machine. J. N. Kenyon, Columbia University.

A continuation of the study published in the October ASTM BULLETIN in order to verify or modify the author's theory of "wave surge" tire fatigue. A much-improved tire fatigue machine is now being used.

New Design of Elastic Proving Bar. C. G. Lutts and Dante Cuozzo, Boston Naval Shipyard.

A design employing a new method of measuring elastic stretch of the proving member is discussed with illustrations. Description of how elongation is measured through the axis of the proving bar with an Ames dial indicator, graduated to read in 0.0001-in. increments, is given. Included are results of comparison tests conducted in an accurate testing machine to illustrate the advantage of measuring elongation through the axis of the proving bar over surface measurements.

A Study of the Geometry of the Tension-Impact Specimen. N. A. Kahn and E. A. Imbembo, U. S. Navy Yard.

Data are presented on the effect of the geometry of the tension-impact specimen on the energy values obtained from the tension-impact test. This paper indicates the effect of the L/D ratio of the test section and includes recommended values of same in order to obtain a true measure of the tensile-impact resistance of metallic materials, as determined by tests conducted in the conventional Charpy pendulum-type impact testing machine. Tension-impact data for medium steel, austenitic type corrosion-resisting steel, copper, Naval rolled brass, nickel-copper alloy (monel), and 17S-T type aluminum alloy at various L/D ratios are included.

A Study of the Tension Test. Earl R. Parker and Harmer E. Davis, University of California.

The paper describes experiments and analyses that were made to study the state of stress at the necked section of a mild steel, cylindrical tension bar just prior to fracture, and to study the transition from a shear to a cleavage type of fracture in the simple tension specimen. Shear fractures in the mild steel were distinguished from cleavage (tensile) fractures by microscopic examination of fractured ferrite crystals using an etch-pit technique. Tension specimens at 70 F. failed entirely by *shear* while at liquid air temperatures similar specimens failed entirely by *cleavage*. The state of stress in the necked section of tension specimens was determined for various strains by measuring the relaxation of residual strains after successive boring operations. A high concentration of longitudinal stress was found in the center of the section, and radial and circumferential stresses of considerable magnitude were found to exist throughout most of the necked section. The shear stress was found to be a maximum in the center of the necked section. This was in agreement with microscopic evidence which showed that shear fractures started in the interior of the bars near the axis of the specimens.

A Method for Predicting Failure of Metals. P. E. Cavanagh, Allen B. DuMont Laboratories, Inc.

Discusses the possibilities of using changes in high-frequency magnetic and eddy current losses to predict failure in metals. The method of recording changes in total magnetic and eddy current losses (or "core losses") is described and examples of stress-core loss curves obtained are given. Correlation between changes in slopes found in these curves and the beginning of plastic deformation is demonstrated by several experiments using static loads applied in tension and repeated loads in tension.

Proof of the fact that this method will detect the beginning of plastic deformation due to overloading or fatigue leads to a practical application in the inspection of mine-hoist cable.

Brinell Hardness of Gray Cast Iron. J. T. MacKenzie, American Cast Iron Pipe Co.

A study has been made of a wide variety of plain and alloyed cast irons from a number of plants. Statistical treatment of the data brings out interesting relations of tensile strength, transverse strength, impact strength, and stiffness to the Brinell hardness of the metal. The ratio of tensile strength to Brinell hardness is shown to be of prime importance.

Wednesday, June 26 9:30 a.m. Eighth Session

Held Simultaneously with the Ninth Session

Symposium on Testing of Parts and Assemblies

Sponsored Jointly by A.S.T.M. and the Society for Experimental Stress Analysis

Fatigue Strength of Lap Joints in Magnesium Sheet Alloys. H. J. Grover and L. R. Jackson, Battelle Memorial Institute.

The results reported in this paper are a portion of the data obtained for the War Metallurgy Division of the N.D.R.C. as a part of the general problem of evaluating magnesium alloys as materials for construction.

The data reported are concerned with the direct-stress fatigue strength of riveted, spotwelded, heliarc-welded, and cycle-welded joints in J-h, J-a, and M-h type magnesium sheet alloys.

Fatigue Characteristics of Magnesium Castings. G. H. Found, The Dow Chemical Co.

The fatigue characteristics of cast magnesium, as determined both from laboratory tests and service experience, are discussed. These pertain to the relative importance of mechanical surface condition, design, surface and subsurface metallurgy, and residual stresses.

Such factors as surface condition and design are shown to have so great an influence as to render fatigue data from polished test bars of limited quantitative use. Subsurface metallurgy and residual stresses, on the other hand, are factors which are of but minor importance in magnesium castings.

Endurance—A Criterion of Design. W. T. Bean, Continental Aviation and Engineering Corp.

In this paper an engine builder takes a "positive" approach to the fatigue problem. It is stated that fatigue failures can be prevented through design analysis.

Endurance strength should be the design criterion of an aircraft engine part—it must withstand high cyclic loads indefinitely. The practical manner in which experimental stress analysis is used to increase the load-carrying capacity of a complex engine structure, prior to endurance testing, is shown.

A "stresscoat" diagnosis of a typical fatigue failure is made. The following design factors are evaluated relative to their effect on the strength of engine components: (1) geometry, (2) material, (3) processing, (4) assembly, (5) critical loads. Emphasis is placed on a part's geometry wherein metal is properly distributed, stress-raisers are eliminated, weight and cost are reduced, and strength increased.

Pneumatic Fatigue Machines. F. B. Quinlan, General Electric Co.

Describes the development and operation of machines for fatigue testing of gas turbine buckets.

(Symposium continued in Tenth Session)

Wednesday, June 26 9:30 a.m. Ninth Session

Held Simultaneously with the Eighth Session

Technical Papers on Cement and Concrete

Permeability of Brick-Mortar Assemblages. John W. McBurney, M. Arnold Copeland, and Russel C. Brink, National Bureau of Standards.

Water-permeability tests were made at 35 days and again after 1 and 2½-yr. exposure on brick-mortar assemblages constructed from ten types of brick and three types of mortars. The 2½-yr. permeability test was made with water solutions of dyes of contrasting colors. This procedure demonstrated extent of bond between brick and mortar and permitted an estimation of the size and nature of through channels. The initial rate of absorption of the bricks had most effect on permeability.

The Influence of Gypsum on the Hydration and Properties of Portland Cement Pastes. William Lerch, Portland Cement Association.

Twelve commercial clinkers, representing the range of chemical composition found in portland cements, were ground in a laboratory mill with various additions of gypsum. The resulting cements were used to study the influence of gypsum on the hydration and properties of portland cement pastes. Five of the clinkers were ground in commercial mills with approximately 1.8 per cent SO_3 to three widely different specific surfaces. The latter cements were used to study the influence of fineness upon the rate of hydration with SO_3 constant.

A conduction calorimeter was used to determine the rate of hydration of neat cement pastes, the rate of hydration being expressed in terms of the rate of heat liberation. Mortar prisms were used to determine the physical properties of the hardened paste—strength, expansion in water, and contraction in air.

Modulus of Elasticity of Aggregates and Its Effect on Concrete. H. A. LaRue, University of Missouri.

The physical properties of concretes are dependent on numerous factors, such as water - cement ratio, proportions of mix, character of the aggregates, and several other features.

It has been observed that some aggregates made more durable concretes than others, hence a study of the effects of various stones has been instituted by the Engineering Experiment Station, in cooperation with the Missouri State Highway Department, in order to determine the relations between physical properties of aggregates and those of concretes in which they have been incorporated. Principal attention has been given to the study of the relations between the modulus of elasticity of the aggregates and that of the concrete.

The aggregates with high values of modulus produce concretes with correspondingly higher modulus than the stones which exhibit low values of modulus of elasticity.

The Use of the Dynamic Modulus of Elasticity in Predicting the 28-Day Flexural Strength of Concrete. E. F. Preece, U. S. Engineer Office.

The so-called sonic analysis has been used extensively to measure the deterioration of the flexural strength of concrete specimens subjected to freezing and thawing. It is equally useful to determine the increase in the flexural strength of concrete specimens with age. When the dynamic modulus at different ages is plotted against the respective age in days the resulting curves have a well-defined pattern. Once this pattern is determined it is practicable to estimate the 28-day dynamic modulus within fairly close limits when the specimen is but ten to twelve days old. This estimated value can then be used to determine the probable 28-day flexural strength from the dynamic modulus-flexural strength relationship which has been shown to be essentially linear in character.

A Method of Particle Size Determination of Soils, Cement, etc., by Means of Chainomatic Specific Gravity Balance. E. V. Barrett, Ministerio, Obras Publicas.

A method of particle size determination of soils, cements, and other fine-grained materials has been developed in the Materials Testing Laboratory of the Ministry of Public Works in Caracas, Venezuela. This method employs a chainomatic specific gravity balance with a 2-ml. spherical glass plummet suspended by a corrosion-resistant steel wire 0.0008 in. in diameter. The method permits the accurate determination of the specific gravity of a suspension of fine particles in a liquid medium at any predetermined depth. The use of this method eliminates the computations and corrections of the hydrometer method and permits the determination of the per cent of soil particles finer than 0.0015 mm. to be made in 72 min. instead of the 24 hr. required by the hydrometer method.

Concrete Flooring with Asphalt Admixture. F. O. Anderegg, John P. Pierce Foundation.

Flooring for human use or for agricultural buildings should be strong enough to give adequate service but should not be too hard and rigid.

A suitable combination of cement and asphalt will produce a floor with much better cushioning action than straight portland cement concrete and capable of giving satisfactory service. In the system developed the asphalt is present as a discontinuous phase.

The resultant alteration of the rheological properties of the concrete is discussed. Formulas are given which have been developed in laying a series of floors in several farm buildings and in a large laboratory, and some of the physical properties are reported.

Wednesday, June 26 1:30 p.m. Tenth Session

Held Simultaneously with the Eleventh Session

Symposium on Testing of Parts and Assemblies (Continued)

Automotive Rear Axles and Means of Improving Their Fatigue Resistance. Oscar J. Horger and C. Lipson, Timken Roller Bearing Co. and Chrysler Corp., respectively.

Discusses laboratory fatigue tests made in rotating bending on 75 full-size actual production automobile rear axle shafts. These shafts were NE 8650 steel, quenched and tempered to about Rc 42.

Fatigue failure developed in the unmachined body portion where a decarburized and scaly surface condition resulted in low fatigue resistance. Some of these shafts were treated to restore the carbon in the surface layers but little improvement was obtained in fatigue strength. Some shafts were shot peened and the endurance limit of these axles was at least twice that of those not peened.

Stress Concentration versus the Fatigue Strength of Engine Components. Charles W. Gadd, Andrew Zmuda, and N. A. Ochiltree, General Motors Corp.

The interpretation of mathematical or experimental stress analyses in terms of actual fatigue strength has been on a somewhat uncertain basis, because of the numerous variables involved, and because checks of fatigue strength against measured or calculated stress have for the most part been on simple arbitrarily shaped specimens. It has not been possible to say whether irregularly shaped structural parts can be manufactured commercially whose strength can be relied upon to agree with theory. In order to help answer this problem, a number of examples of stress analyses together with the corresponding fatigue test data have been assembled. Within the range of specimen types analyzed, which includes only carefully fabricated high-strength steel components, agreement has been reasonably good, and it is felt that the practical utility of a design analysis is substantiated.

Investigation of Materials for Marine Propellers, William C. Stewart, U. S. Navy.

This work involves the investigation of approximately thirty different alloys as a basis for selecting suitable materials for marine propellers, particularly for thin blade propellers for high-speed boats. Most of the alloys were obtained in the form of cast plates 12 by 12 by 2 to 2½ in. thick as it was considered that the properties obtained for these castings would be representative of the materials when cast in a propeller. The tensile properties including the elastic properties in tension and compression are reported. Other test results include: Brinell hardness, Charpy impact, endurance, and corrosion-fatigue tests in salt water, and modulus of elasticity determinations. The resistance to hydraulic cavitation was determined by means of a vibratory apparatus employing the magneto-striction of a nickel tube to provide oscillation. The materials were tested, partially submerged, in continuously renewed Severn River water for over 500 days to reveal any tendency to local attack and dezincification.

Wednesday, June 26 2 p.m. Eleventh Session

Held Simultaneously with the Tenth Session

Presentation of Report of Committee D-2

Symposium on Oil Procurement Practices (Continued)

Report of Committee D-2 on Petroleum Products and Lubricants. T. A. Boyd, Chairman.

Symposium on Oil Procurement Practices (Continued). Discussion of practices in industry will be given by the following three men:

B. C. Voshell, Socony-Vacuum Oil Co.
James Costello, Bureau of Ships.
J. L. McCloud, Ford Motor Co.

Wednesday, June 26 3 p.m.

PAPERS ON PAINT

At the afternoon meeting of Committee D-1 on Paint, Varnish, Lacquer, and Related Products the following papers will be presented. All those interested in these papers are cordially invited to attend.

A Method of Obtaining the Particle Size Colloids from Sedimentation Data Obtained with the Sharples Supercentrifuge. S. A. Loukomsky and S. J. O'Brien, Calco Chemical Division of American Cyanamid Co.

Principles of Immersion and Humidity Testing of Metal Protective Paints. A. C. Elm, The New Jersey Zinc Co. (of Pa.)

Wednesday, June 26 4:30 p.m. Twelfth Session

Marburg Lecture, Award of Dudley Medal

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials.

Twentieth Edgar Marburg Lecture, "Protective Organic Coatings as Engineering Materials." J. J. Mattiello, Hilo Varnish Corp.

[*See news article on Lecture, p. 9*]

Award of Charles B. Dudley Medal To H. R. Copson.

The Nineteenth Award of the Charles B. Dudley Medal will be made to H. R. Copson, Research Chemist, Research Laboratories, The International Nickel Co., Inc., Bayonne, N. J., for his paper on "A Theory of the Mechanism of Rusting of Low Alloy Steels in the Atmosphere," published in the 1945 *Proceedings*.

An annual award is made to the author or authors of a paper of outstanding merit constituting an original contribution on research in engineering materials. Established as a means of stimulating research in materials and of recognizing meritorious contributions, it commemorates the name of the first President of the Society.

Richard L. Templin Award

The Richard L. Templin Award was established in 1945 when the Executive Committee received a gift from Richard L. Templin to be used for a prize award for papers describing new testing methods and apparatus. The purpose of the award is to stimulate research in the development of testing methods and apparatus, to encourage the presentation to the Society of papers describing new and useful testing procedures and apparatus, and to recognize meritorious efforts of this kind.

The first Richard L. Templin Award will be made to R. C. Brumfield, Instructor in Mechanical Engineering, California Institute of Technology, Pasadena, California for his paper on "A Sulfur Print Method for the Study of Crack Growth in the Corrosion-Fatigue Metals" published in the 1945 *Proceedings*. However, as Mr. Brumfield is unable to come East for the Annual Meeting the will be made at a District Meeting in California sometime in the Fall.

Wednesday, June 26 7 p.m.

Annual Dinner

Presidents Address; Guest Speaker; Awards

The Program Committee of the Buffalo Committee on Arrangements has arranged a dinner meeting as a feature of the annual meeting. At this dinner the retiring president, John R. Townsend, Bell Telephone Laboratories, will give his President's Address which this year will embody conclusions from his extensive experience as Materials Standards Engineer and Materials Engineer with Bell Laboratories and his extensive work during both peace and war on a wide variety of important problems.

Joining the President as guest speaker at the dinner will be Dr. Bernard Keble Sandwell, Managing Editor of *Saturday Night* one of Canada's most widely read weekly news periodicals. A gifted public speaker with an intriguing sense of humor, Dr. Sandwell will unquestionably find a very cordial welcome in Buffalo.

Thursday, June 27 9:30 a.m. Thirteenth Session

Held Simultaneously with the Fourteenth Session

Session on Effect of Temperature on the Properties of Metals—Materials for Gas Turbines

Heat-Resisting Metals for Gas Turbine Parts. Howard C. Cross and Ward F. Simmons, Battelle Memorial Institute.

Heat-resisting alloys of the nickel-chromium-iron, nickel-chromium, cobalt-iron, nickel-chromium-cobalt, and cobalt-chromium types, strengthened by various alloy additions have been studied to determine their properties and suitability for turbosupercharger and gas turbine service. Both cast and wrought alloys were studied, and the effects of heat treatment were determined. Tension, impact, stress-rupture, and creep properties over the temperature range 1350 to 1600 F., and stress-rupture properties at 2000 F., have been determined. For the better alloys studied, design curves relating stress, temperature, time, total deformation, and rupture life are presented.

High-Temperature Alloys Developed for Aircraft Turbosuperchargers and Gas Turbines. J. W. Freeman, E. E. Reynolds, and A. E. White, University of Michigan.

The paper presents data and metallurgical characteristics for the new heat-resistant alloys which have been developed through work sponsored at the University by the N.A.C.A. These alloys were intended for use as wheel or bucket materials for turbosuperchargers, jet engines and gas-turbine engines for aircraft. In all, 90 to 100 alloys are covered briefly by physical properties at room temperature and stress-rupture data at 1200 F. The better alloys are more completely covered at 1200 F. and their characteristics at 1350, 1700 and 1800 F. are shown.

Chromium-Base Alloys. Robert M. Parke and Frederick P. Bens, Climax Molybdenum Co.

Research on new refractory alloys in which chromium is the alloy base is described. Certain properties of chromium-base alloys pertinent to their possible use as gas turbine blades operating at 1350 and 1600 F. are presented. Some of the special methods of making and shaping the alloys are briefly described. The chromium-rich portions of thirteen binary and nine ternary systems were studied in an exploratory manner.

An alloy which appears interesting for use at 1350 F. contains 60 per cent chromium, 15 per cent molybdenum, and the balance iron. This alloy, in a stress-rupture test, supported a stress of 50,000 psi. for 1414 hr., with 8.0 per cent elongation and 6.2 per cent reduction of area.

An alloy having interesting properties at 1600 F. contains 60 per cent chromium, 25 per cent molybdenum, and the balance iron. In a stress-rupture test it supported a stress of 30,000 psi. for 430 hr., with 6 per cent elongation and 6.3 per cent reduction of area.

Application of High-Temperature Alloys to Correct Gas Turbine Designs. F. S. Badger, Jr., and W. O. Sweeney Jr., Haynes-Stellite, Kokomo, Ind.

Alloys and Ceramic Materials for High-Temperature Service. A talk by Howard C. Cross, Battelle Memorial Institute.

Discusses results of work being carried on under contract with the Office of Research and Inventions, Navy Department. Five different subjects are being covered: (1) engineering properties of heat-resisting alloys, (2) chromium-base alloys, (3) fundamental factors promoting high-temperature strength of alloys, (4) fundamental investigation on the causes of cracking in welds and adjacent parent metal, and (5) fundamental studies of ceramic materials.

The plan of the research and the results obtained in the various phases will be presented.

(Session continued in Seventeenth Session)

Thursday, June 27 9:30 a.m. Fourteenth Session

Held Simultaneously with the Thirteenth Session

Symposium on pH Measurements

Historical Review of the Hydrogen Electrode and the Calomel Cell in the Measurement of Hydrogen Ions. C. N. Myers.

As a complete presentation of a historical review of the hydrogen electrode and the calomel cell, used in the measurement of hydrogen ions, would be far too extensive to be covered in a technical paper for this symposium, the author has confined this paper to a brief discussion of the osmotic theory, the theory of indicators, the concepts of electrolytic dissociation, solution tension, and contact potential. The thermodynamic derivation of the emf. of a concentration cell is included.

Theoretical Considerations in the Choice and Definition of the pH Scale. J. K. Warner, D. S. McKinney and J. P. Fugassi, Carnegie Institute of Technology.

Standard Buffer Solutions. G. G. Manov, National Bureau of Standards.

Details are presented concerning the purification of buffer salts, the preparation and the pH values of various buffer solutions and the manner in which the pH values are assigned, the stability of aqueous buffers, and the methods used for the calibration of pH instruments.

Recent Advances in the Theory and Use of Glass Electrodes for pH Determinations. M. Dole, Northwestern University.

Reviews papers on the glass electrode which have appeared in the world's scientific literature since the publication in 1941 of the author's monograph entitled "The Glass Electrode." The chief subjects concerning the glass electrode about which most papers recently have been written are (1) the study of the mechanism of the glass electrode; (2) the study of the glass electrode at high temperatures, at high pH's and in non-aqueous solutions; (3) the study of the asymmetry potential; and (4) the adaptation of the glass electrode to unusual systems. The behavior of the glass electrode in pure water and unbuffered salt solutions has been investigated, but more work needs to be done in this field, particularly in the region of strong brines.

(Symposium continued in Fifteenth Session)

Thursday, June 27 2 p.m. Fifteenth Session

Held Simultaneously with the Sixteenth Session

Symposium on pH Measurements (Continued)

Precautions to Be Observed in Making Colorimetric pH Determinations. F. R. McCrumb, W. A. Taylor and Co.

Discusses the possible sources of error in the practical application of pH. The influence of salts, colloids, color, turbidity, oxidizing and reducing agents, as well as materials having specific influences on indicators, is dealt with and methods of overcoming errors are recommended. Methods for securing accuracy on slightly buffered materials are covered in some detail.

Acid-Base Equilibria in Aqueous and Non-aqueous Solutions. Martin Kilpatrick, University of Pennsylvania.

The question of an acidity scale in the absence of water is discussed for acidic, basic, and aprotic solvents and relative acid strength scales set up for various solvents. The problem of a general acidity scale for proton acids without hydrogen is presented.

The Potentiometric Estimation of Hydrogen Ion Concentration in Nonaqueous Media. L. Lykken, Shell Development Co.

Thursday, June 27 2 p.m. Sixteenth Session

Held Simultaneously with the Fifteenth Session

Presentation of Reports of Committees on Ferrous Metals, Paints, and Miscellaneous Subjects

Committee A-1 on Steel. N. L. Mochel, Chairman.

Committee A-2 on Wrought Iron. C. B. Bryant, Chairman.

Committee A-3 on Cast Iron. J. T. MacKenzie, Chairman.

Committee A-5 on Corrosion of Iron and Steel C. D. Hocker, Chairman.
A Statistical Analysis of the Total Immersion Tests of A.S.T.M. Subcommittee V of Committee A-5. V. V. Kendall, National Tube Co.

Committee A-6 on Magnetic Properties. Thomas Spooner, Chairman.

Committee A-7 on Malleable-Iron Castings. C. O. Burgess, Chairman.

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. J. H. Critchett, Chairman.

Committee D-1 on Paint, Varnish, Lacquer, and Related Products. W. T. Pearce, Chairman.

Committee E-1 on Methods of Testing. W. H. Fulweiler, Chairman.

Committee E-3 on Chemical Analysis of Metals. G. E. F. Lundell, Chairman.

Committee E-4 on Metallography. L. L. Wyman, Chairman.

Committee E-6 on Methods of Testing Building Constructions. L. J. Markwardt (pro tem), Chairman.

Committee E-7 on Radiographic Testing. H. H. Lester, Chairman.

Committee E-8 on Nomenclature and Definitions. P. V. Faragher, Chairman.

Joint Research Committee on Filler Metal. J. H. Deppeler, Chairman.

Committee E-2 on Spectrographic Analysis. H. V. Churchill, Chairman.

Thursday, June 27 3 p.m.

PAPER ON ADHESIVES

At the meeting of Committee D-14 on Adhesives the following lecture is being given. All those interested in this paper are cordially invited to attend.

Discussion of a Fundamental Theory of Adhesion. Woldemar A. Weyl, Pennsylvania State College

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Thursday, June 27 8 p.m. Seventeenth Session

Held Simultaneously with the Eighteenth and Nineteenth Sessions

Session on Effect of Temperature on the Properties of Metals—General (Continued)

Report of Joint Research Committee on Effect of Temperature on the Properties of Metals. N. L. Mochel, Chairman.

The Effect of Carbide Spheroidization Upon the Rupture Strength and Elongation of Carbon-Molybdenum Steel. S. H. Weaver, General Electric Co.

A commercial plate of carbon-molybdenum steel was placed in twelve specially chosen conditions by heat treatment and carbide spheroidization. Samples in each condition were tested in long-time creep at 900 F. and duplicate specimens at 1000 F. as reported to A.S.T.M. in 1941. The present paper describes how the same steel in the same twelve conditions has been subjected to long-time rupture stress and elongation tests.

There is a tendency for the initial and aged conditions to approach a common stable rupture stress. During a long service life, the rupture stress for 10,000 hr. does not decrease nearly as much as the creep stress, but the rupture elongation rapidly drops with time for all conditions except those with initially spheroidized carbides.

Compressive Properties of Aluminum Alloy Sheet at Elevated Temperatures. Alan E. Flanigan, Leslie F. Tedsen, and John E. Dorn, University of California.

Describes an apparatus that has been developed to allow the compression testing of sheet materials at elevated temperatures. It includes a testing fixture, a special extensometer, and an oil-bath furnace which are described in detail. The short-time compressive properties of five high-strength aluminum alloy sheet materials have been determined at temperatures up to 300 F. after exposures ranging from ½ to 1000 hr. The materials include 24S-T, 24S-T81, 24S-T86, R301-T, and 75S-T. The effects of temperature and time on compressive yield stress are compared with those for the corresponding tensile properties and it is found that approximate values of compressive yield stress may be derived from calculations based upon the tension values.

Tensile and Creep Strengths of Some Magnesium-Base Alloys at Elevated Temperature. A. A. Moore and John C. McDonald, The Dow Chemical Co.

Describes the apparatus and technique used for making creep tests, up to and including rupture, which were carried out for periods of 1000 hr. A number of commercial alloys, as well as some experimental cerium-containing alloys, were studied.

At room temperature it was observed for many of the alloys that the yield strength was an adequate criterion for design of parts to be steadily loaded for long periods. At the maximum temperature of test, 300 F., this is true of cerium-containing alloys, but the commercial alloys have strengths to rupture less than the yield strength. The magnesium-manganese alloy, M-1, is the best of the commercial alloys in respect to creep properties at elevated temperature.

Magnesium-base alloys do not lose ductility at rupture under long-time conditions of loading.

Resistance of Iron-Nickel-Chromium Alloys to Oxidation in Air at 1600 to 2200 F. Oscar E. Harder, Battelle Memorial Institute.

Influence of Strain Rate and Temperature on the Mechanical Properties of Monel Metal and Copper. D. J. McAdam, Jr., G. W. Geil, and D. H. Woodard, National Bureau of Standards.

The third state of creep may be initiated by the formation of microscopic cracks, predominantly intercrystalline. Cracking begins when the rising true stress reaches a technical cohesion limit determined by the temperature, strain rate, and amount of plastic deformation; the disintegration then continues to complete fracture. The second-stage flow stress, the cohesion limit, and the ductility increase with decrease in temperature and with increase in the strain rate. By combining these new results with previously published data, the view is broadened to include a range from −188 C. to the melting point.

Thursday, June 27 8 p.m. Eighteenth Session

Held Simultaneously with the Seventeenth and Nineteenth Sessions

Symposium on Atmospheric Weathering of Corrosion-Resistant Steels

Results of 15-yr. Exposure Tests on Corrosion-Resistant Steel. I. V. Williams and K. G. Compton, Bell Telephone Laboratories, Inc.

This paper discusses the results of the exposure of ten corrosion-resistant steels to New York City atmosphere for 15 yr. These steels represented five different alloys and were manufactured by four different companies. The loss in tensile strength of all alloys was small. The 13 per cent chromium steels showed considerable surface rust. The 18 per cent chromium–8 per cent nickel and the 17 per cent chromium steels rusted slightly.

Atmospheric Corrosion Tests on Corrosion-Resistant Steel. Grant L. Snair, Jr., Allegheny Ludlum Steel Corp.

The results of atmospheric corrosion tests on the straight chromium, chromium-nickel, and modified chromium-nickel steel alloys are reported as observed by visual examinations of the corroded specimens during the testing period and after 10-yr. exposure in an industrial atmosphere of average pollution. The methods of specimen preparation and exposure are briefly discussed. The descriptions show how the resistance of the metal to atmospheric corrosion is affected by composition, surface finishes, heat treatment, welding, and contact with other metals.

Atmospheric Corrosion Tests on High-Chromium Steels. W. O. Binder and C. M. Brown, Union Carbide and Carbon Research Laboratories, Inc.

Results of corrosion tests in marine and industrial atmospheres on low-carbon 0 to 18 per cent chromium steel show that increased corrosion resistance is obtained by raising the chromium content, and that about 18 per cent chromium is required to make the steels virtually corrosion resistant in the atmospheres tested. Steels containing 18 per cent chromium, together with about 8 per cent nickel, of the type currently used in lightweight construction, also have excellent atmospheric corrosion resistance and retain their strength and ductility after 5-yr. exposure in an industrial atmosphere. Steels of this latter type also retain their corrosion resistance in a marine atmosphere when exposed in highly stressed conditions.

Weathering Behavior of Corrosion-Resistant Steel Insect Screens. W. A. Wesley and H. R. Copson, The International Nickel Co.

The results of several series of atmospheric corrosion tests are presented in which commercially woven wire cloth screens of bronze and of types 302 and 316 corrosion-resistant steel were exposed in sulfurous, industrial, marine, and rural atmospheres. Although some of the tests will not mature for years, certain conclusions can be drawn at this stage. Type 302 corrosion-resistant steel wire cloth is too susceptible to pitting if partly sheltered from rain in industrial and marine atmospheres to outlast bronze similarly sheltered. Type 316 corrosion-resistant steel insect screens are showing phenomenal resistance to corrosion in industrial atmospheres whether sheltered or not. Other advantages of type 316 over bronze screens include freedom from staining of white paint, high strength, clearer vision, and greater ease of cleaning.

Marine Exposure Tests of Corrosion-Resistant Steel Sheet. W. H. Mutchler, National Bureau of Standards.

Chromium-nickel steel sheets of the 18–8 type were exposed to the weather or to sea water at three marine localities. The objectives were to determine the effect upon corrosion of (1) small amounts of alloying elements such as molybdenum, titanium, or columbium; (2) locality of exposure; (3) shot welding; (4) various surface treatments and finishes; and (5) contact with dissimilar metals. Damage owing to corrosion was evaluated chiefly by means of flexural fatigue tests, supplemented by macroscopic examinations.

Corrosion-Resistant Steel for Architectural and Structural Applications. H. A. Grove, Republic Steel Corp.

The paper deals with a survey made by a Special Subcommittee of Subcommittee IV on Methods of Corrosion Testing of A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys for the purpose of observing the effect of atmospheric corrosion on architectural and structural applications in different localities and conditions such as the Chrysler and Empire State Buildings in New York City; the Philadelphia Saving Fund Society Building in Philadelphia; the DuPont Exhibit Building, M. Gettleman, Appollo Theater, and Regis Restaurant in Atlantic City, N. J.

The structural applications inspected were a corrosion-resistant steel train "The Crusader" and the corrosion-resistant deck houses on two destroyers—the Alwyn and the Farragut. The results observed shown corrosion-resistant steel to be well suited for such applications.

Atmospheric Corrosion Tests of Corrosion-Resistant Steel Wires. A. P. Jahn, Bell Telephone Laboratories, Inc.

Subcommittee VIII on Field Tests of Metallic Coatings of Committee A-5 on Corrosion of Iron and Steel is conducting an atmospheric corrosion test on wire and wire products. The test, now in its tenth year, includes wire specimens of 12 to 14 per cent chromium steel and 18 per cent chromium-8 per cent nickel steel. Visual examinations have shown no marked corrosion of these wires. In general the 18–8 wires have retained their metallic luster. The 12 to 14 per cent chromium wires have shown some superficial discoloration. Tension tests have been made on some of the exposed specimens. None of the wires tested has shown any significant change in tensile strength.

Thursday, June 27 8 p.m. Nineteenth Session

Held Simultaneously with the Seventeenth and Eighteenth Sessions

Symposium on Freezing-and-Thawing Tests of Concrete

The Symposium on Procedures for Making Freezing-and-Thawing Tests of Concrete, sponsored by Committee C-9 on Concrete and Concrete Aggregates will afford an opportunity for round-table discussion of the procedures used by different investigators for evaluating the durability of concrete. Following a lead paper by Prof. Withey, of the University of Wisconsin, there will be ten short contributions by leading authorities listed below. Topics to be discussed in detail will include principal objectives in making freezing-and-thawing tests, test procedures, and methods used for evaluating the results of freezing and thawing (sonic methods, length changes, etc.). Following the scheduled papers there will be general discussion from the floor.

C. W. Allen, Ohio State Highway Testing and Research Lab.
R. F. Blanks, U. S. Bureau of Reclamation.
R. E. Davis, University of California
A. T. Goldbeck, National Crushed Stone Association.
F. V. Reagel, Missouri State Highway Commission.
C. H. Scholer, Kansas State College of Agriculture.
Bailey Tremper, State Department of Highways, Washington.
R. C. Valore, Jr., National Bureau of Standards.
Fred F. Bartel National Sand and Gravel Association.
C. E. Wuerpel, Central Concrete Laboratory, U. S. Army.

Considerations Involved in the Making of Freezing-and-Thawing Tests on Concrete. M. O. Withey, University of Wisconsin.

The paper emphasizes the importance of a knowledge of the weathering resistance of concrete. The objective of the test and the desired acceleration of the rate of disintegration without modification in the process of disintegration is stressed. Factors influential in developing freezing-and-thawing tests and the types of tests commonly used are considered. The more important details of procedure for testing concrete containing aggregate of uncertain quality, the principal indices of damage, and the selection of the end point are discussed. A brief consideration is also made of the significance of freezing-and-thawing tests and the further research which is needed to provide proper standards for procedure.

Friday, June 28 9:30 a.m. Twentieth Session

Held Simultaneously with the Twenty-First Session

Presentation of Reports of Committees on Cement, Concrete, Lime, Refractories, Masonry Materials

Committee C-1 on Cement. F. H. Jackson, Chairman.

Committee C-5 on Fire Tests of Materials and Construction. S. H. Ingberg, Chairman.

Committee C-7 on Lime. W. C. Voss, Chairman.

Committee C-8 on Refractories. J. D. Sullivan, Chairman.

Committee C-9 on Concrete and Concrete Aggregates. F. E. Richart, Chairman.

Sanford E. Thompson Award.

To C. W. Muhlenbruch, Associate Professor of Civil Engineering, Carnegie Institute of Technology.

The Fifth Sanford E. Thompson Award will be made to C. W. Muhlenbruch, Associate Professor of Civil Engineering, Carnegie Institute of Technology, for his paper on "The Effect of Repeated Loading on the Bond Strength of Concrete," published in the 1945 *Proceedings*. The Sanford E. Thompson Award was established in 1938 by Committee C-9 on Concrete and Concrete Aggregates as an annual token of recognition to the author or authors of a paper of outstanding merit on concrete and concrete aggregates presented at an annual meeting of the Society. The award is named in honor of the first chairman of the committee.

Committee C-12 on Mortars for Unit Masonry. Theodore I. Coe, Chairman.

Committee C-13 on Concrete Pipe. T. F. Doll, Chairman.

Committee C-14 on Glass and Glass Products. Louis Navias, Chairman.

Committee C-15 on Manufactured Masonry Units. D. E. Parsons, Chairman.

Committee C-16 on Thermal Insulating Materials. E. T. Cope, Chairman.

Committee C-18 on Natural Building Stones. W. C. Clark, Chairman.

Friday, June 28 9:30 a.m. Twenty-first Session

Held Simultaneously with the Twentieth Session

Presentation of Reports of Committees on Non-Ferrous Metals and Miscellaneous Materials—Technical Papers on Insulating Oils

Committee B-1 on Wire for Electrical Conductors. J. H. Foote, Chairman.

Committee B-2 on Non-Ferrous Metals and Alloys. E. E. Thum, Chairman.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. H. S. Rawdon, Chairman.

Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys. J. W. Harsch, Chairman.

Committee B-5 on Copper and Copper Alloys, Cast and Wrought. G. H. Harnden, Chairman.

Committee B-6 on Die-Cast Metals and Alloys. J. R. Townsend, Chairman.

Committee B-7 on Light Metals and Alloys, Cast and Wrought. D. L. Colwell, Chairman.

Committee B-8 on Electrodeposited Metallic Coatings. R. J. McKay, Chairman.

Committee B-9 on Metal Powders and Metal Powder Products. W. A. Reich, Chairman.

Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

Committee D-5 on Coal and Coke. A. C. Fieldner, Chairman.

Committee D-7 on Wood. Hermann von Schrenk, Chairman.

Committee D-9 on Electrical Insulating Materials. M. P. Davis, Chairman.

Water Determination in New and Used Insulating Oils by Doble Method. Frank C. Doble, Doble Engineering Co.

Electrical Quality Classification of Raw Mica by a Rapid, Direct-Reading Test Method, K. G. Coutlee, Bell Telephone Laboratories, Inc.

The rapid direct-reading test method for classifying dielectric loss of raw mica 0.010 to 0.030 in. thick in terms of Q at 1 megacycle, specified in A.S.T.M. Tentative Specification for Natural Block Mica and Mica Films, Suitable for Use in Fixed Mica-Dielectric Capacitors (D 748–45 T) has been the subject of a round-robin test by Subcommittee IX on Mica Products of Committee D-9 on Electrical Insulating Materials. Tests were made by five consumers and two producers of mica on samples of electrically selected low visual quality block mica of 14 different types and various colors from world wide sources.

Committee D-10 on Shipping Containers. Edward Dahill, Chairman.

Committee D-11 on Rubber and Rubber-Like Materials. Simon Collier, Chairman.

Committee D-12 on Soaps and Other Detergents. B. S. Van Zile, Chairman.

Committee D-13 on Textile Materials. H. J. Ball, Chairman.

Committee D-14 on Adhesives. R. C. Platow, Chairman.

Committee D-16 on Industrial Aromatic Hydrocarbons. J. M. Weiss, Chairman.

Committee D-17 on Naval Stores. V. E. Grotlisch, Chairman.

Committee D-19 on Water for Industrial Uses. Max Hecht, Chairman.

Joint Research Committee on Boiler Feedwater Studies. C. H. Fellows, Chairman.

Committee D-20 on Plastics. Robert Burns, Chairman.

Friday, June 28 2 p.m. Twenty-second Session

Held Simultaneously with the Twenty-third and Twenty-fourth Sessions

Technical Papers on Plastics and Wood

Tension and Torsion Creep Properties of Cloth Laminates. Joseph Marin, Pennsylvania State College.

The purpose of this paper is to report tension and torsion creep test data on three cloth-based laminates. Creep tests were made for round and tubular specimens and the data were interpreted by three methods—the log-log, the semi-log, and the hyperbolic sine methods. A theoretical correlation is given between the tension and torsion creep values based on a distortion energy criterion. This correlation permits the prediction of torsion creep deformations when creep constants for tension are known. In order to select the stress values to be used for the creep tests and to obtain complete information on the static properties, tension, compression, and torsion stress-strain diagrams were taken for each material.

Effect of Weathering on Insulation Resistance of Plastics. Leslie H. Campbell, Arthur H. Falk, and Robert Burns, Bell Telephone Laboratories, Inc.

The deleterious effect of sunlight on hard-rubber and other of the older insulators is well known. The purpose of this paper is to furnish similar information on many of the plastics of commerce. The separate effects of direct exposure, as well as under glass, are given. Data on the degrading power of light alone, and heat alone, are presented. Since most communication apparatus is engineered for long life, and cannot be kept in darkness or entirely out of the weather, the data suggest discretion in the choice of plastics. As a class they are unusually good. If properly chosen and engineered they will serve the electrical engineer well.

Effect of Temperature and Humidity on Mechanical Properties of Molded Cellulose Acetate Plastics. W. E. Welch, R. F. Hayes, T. S. Carswell, and H. K. Nason, Monsanto Chemical Co.

Four molding compound formulations, covering a range of flow gradings, were prepared from medium-acetyl (37.7 per cent) and four from high-acetyl (41.0 per cent) cellulose acetate. Test specimens were injection molded from these formulations and physical properties were determined by standard A.S.T.M. procedures. The effects on yield and ultimate strengths in tension, elongation, modulus of elasticity, yield strength in flexure, and impact strength, resulting from variations in ambient temperature over the range from −25 C. (−13 F.) to 80 C. (176 F.), and of variation in relative humidity at 25 C. (77 F.) over the range from 0 per cent to saturation, were determined, and the results are shown in graphical form. Some data showing the effect of exposure to weather on tensile properties of two of the formulations are presented also. The practical importance of these data is discussed.

Methods for Determining the Specific Gravity of Wood and Wood-Base Materials. L. J. Markwardt and B. H. Paul, Forest Products Laboratory.

Details for a variety of methods of making specific gravity determinations on wood and wood-base materials, and involving specimens of any size and shape, are presented. Featured is a check list for selecting the method most suitable for a given purpose, when the size and moisture condition of the sample, and other considerations such as degree of accuracy and limitations of time and facilities are known. The degree of accuracy required and the equipment needed for special types of materials or shapes of specimens are discussed, as well as special problems relating to wood. Included also are descriptions of short-cut and production methods which make specific gravity more useful as a working tool for evaluating wood and wood-base materials. Data are presented to show the accuracy and comparability of results by different methods.

Friday, June 28 2 p.m. Twenty-third Session

Held Simultaneously with the Twenty-second and Twenty-fourth Sessions

Technical Papers on Non-Ferrous Metals

The Notch Sensitivity in Static and Impact Loading of Some Magnesium-Base and Aluminum-Base Alloys. J. P. Doan and J. C. McDonald, Dow Chemical Co.

The effect of a wide variety of stress concentrations and loading conditions on the strength, ductility, and toughness of a number of magnesium-base and aluminum-base alloys was determined. Attention was concentrated on the higher strength compositions among the aluminum-base alloys. It was found to be impossible to derive sensitivity indices of general applicability. Different tests gave different results. Nevertheless, an attempt was made to draw conclusions of a general sort which would aid in estimating the performance of these materials in loaded parts.

Atmospheric and Indoor Aging Studies on Some Aluminum and Zinc-Base Die-Casting Alloys. G. R. Gohn and Lucille E. Menges, Bell Telephone Laboratories, Inc.

Results of 15-yr. indoor and outdoor aging studies on 12 aluminum and 9 zinc-base die-casting alloys are discussed. These tests were made on the same alloys as those used by A.S.T.M. Committee B-6 on Die-cast Metals and Alloys in its studies. However, the outdoor exposure conditions differed from those used by the committee in that the specimens were exposed to an accelerated corrosion environment for the first 6 yr. Data are presented showing the changes in tensile strength and elongation for intermediate periods. While all of the zinc-base alloys and all but three of the aluminum-base alloys are no longer in commercial use, the data presented complete the cooperative studies originally undertaken in 1927 and supplement the published data of Committee B-6.

Evaluation of the Forming Properties in Bending of Five Commercial Sheet Aluminum Alloys. G. R. Gohn and S. M. Arnold, Bell Telephone Laboratories, Inc.

Due to the widespread use of formed sheet in manufacture, information must be available to the designer and to the shop regarding the minimum radius material may be bent without degradation, particularly where there are space limitations. In this paper data are given on the forming characteristics of several aluminum alloys in sheet form both for bending brakes and punch presses. An easily adjusted bending brake, useful for test purposes, is decribed.

Creep Tests on Some Lead and Lead Alloy Sleeves and Tapes. G. R. Gohn, S. M. Arnold, and G. M. Bouton, Bell Telephone Laboratories, Inc.

Data are reported giving the results of long-time tension (creep) tests on specimens of both commercial and experimental lead and lead alloys of various compositions. The tests extended over a period of 8 yr. In the study, stresses ranged from relatively short-time rupture stresses down to those of the order of 100 psi. A number of curves are presented showing the relation between stress and elongation. Data are included showing the effect of temperature on the creep resistance.

A Permeameter for Metals Used in Cathode-Ray and Television Tubes. H. J. Evans, Radio Corporation of America.

The construction and calibration of an inexpensive permeameter for rapid routine measurements of paramagnetic alloys of low permeability are described. The permeameter can be used to measure the permeability of metal samples in the form of wire, strip, rod, tubing, or any sample whose cross-section is constant throughout its length. Values of the permeability of metals can be accurately determined to ±1 in the fourth decimal place for metals whose permeabilities lie below 1.0050. Application of the permeameter is made to the measurement of the permeability of six alloys which have been used in RCA cathode-ray and television tubes.

Compressive Stress-Strain Properties of Aircraft Materials. P. E. Sandorff and R. K. Dillon, Lockheed Aircraft Corp.

A series of compressive tests of most commonly used aircraft materials was made to determine the shape of the compressive stress-strain curves and tangent modulus *versus* compressive stress curves corresponding to typical properties and to specified minimum, or "allowable," properties.

In reducing the test data it was assumed that all stress-strain curves representing different strength properties for material of a particular manufacturing specification could be considered affinely related. On this basis all related data were reduced to a single curve, representing an average shape for material of specified minimum properties. Accuracy of the order of one per cent is preserved.

Friday, June 28 2 p.m. Twenty-fourth Session

Held Simultaneously with the Twenty-second and Twenty-third Sessions

Bituminous Materials

Report of Committee D-4 on Road and Paving Materials. Shreve Clark, Chairman.

Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials. J. S. Miller, Chairman.

Report of Committee D-18 on Soils for Engineering Purposes. E. J. Kilcawley, Acting Chairman.

Ten Years' Outdoor Exposure of Filled Asphalt Coatings on Saturated Felts. G. L. Oliensis, Lloyd A. Fry Roofing Co.

Past exposure tests on filled coatings have been made on small, rigid, aluminum panels, usually in the weatherometer for relatively short periods, and have indicated that nearly all fillers improve the weatherability of asphalt, some fillers more than others.

The author has exposed coatings outdoors on asphalt-saturated felt for approximately ten years. These tests indicate that fillers do stabilize the flow and thereby improve the life of roofing cements of relatively low softening point, which have a tendency to flow or sag when unfilled; but that fillers do not seem to improve the crack resistance of coatings of higher softening point which do not flow when unfilled.

Development of a Method of Test for Evaluating Soil Bituminous Materials. E. O. Rhodes and P. F. Phelan, Koppers Co.

Laboratory Investigation of Anti-stripping Admixtures Used for Promoting Power and Adhesion Between Bitumens and Aggregates. J. C. Sprague, U. S. Army Corps of Engineers.

The general relations between, and effect of antistripping admixtures upon, the wetting power, adhesion, and stability of bituminous mixtures in the presence of water have been investigated for combinations involving nine additives, nine aggregates and three bitumens. Findings based upon a conventional static immersion stripping test, and upon a stability test of soaked *versus* unsoaked specimens are presented, and discussed. It is stressed that coverage of an aggregate with bitumen may often be obtained without adhesion—but that thorough wetting of an aggregate is essential to good adhesion.

Strength of Molded Phenolic Parts

MOST of the available data on the strength of molded phenolic plastics have been obtained with standard test specimens and standard methods of test. Specific data of this type, obtained in accordance with test methods established by the American Society for Testing Materials, are published in manufacturers' data books. These sources acknowledge that a "molding material, which on standard test pieces appears superior, may show up in actual production as being even inferior to another material which on standard test pieces reveals a lower order of desirable properties." They attribute these discrepancies to such factors as peculiarities in mold design, size and shape of the molded article, and variations in molding conditions, but not to inherent differences in the materials or to selective characteristics of the standard test specimens.

An investigation of the nebulous region between standard test and structural performance of molded plastics has been conducted at the Bureau for the National Advisory Committee for Aeronautics. It was observed that nonuniformity of a material affects the results of tests made with specimens of different sizes and with different methods of loading. The strength values were found to depend on the relationship between the size and shape of the molded specimen and the size and shape of the fillers. The most significant variations observed within a diversified group of materials were found to depend on the orientation of fibrous fillers. Of secondary importance was the dependence of the variability of test results on the size of the filler particles incorporated into the molding powder, as well as on the size of the molded piece. It is interesting to note that the trends observed in this investigation for the behavior of standard plastic test specimens agree qualitatively with conclusions derived from statistical analysis of the effects of dimensions and methods of loading upon the strength properties of concrete beams. —From the March, 1946, *Technical News Bulletin*, National Bureau of Standards.

Analysis of Standard Sample of Carburetted Water-Gas

THE following note excerpted from the March issue of the National Bureau of Standards *Technical News Bulletin* will be of interest to a number of the members:

"The Journal of Research for March contains a report (RP1704) by Martin Shepherd on the analysis of a standard sample of carburetted water-gas by 24 laboratories in cooperation with Subcommittee VII of Committee D-3 of the American Society for Testing Materials. The data are presented in a series of frequency-distribution plots, which show at a glance how the analyses compare with respect to each component of the gas mixture, as well as the calculated heating value and specific gravity. These plots form a clear picture of this type of gas analysis in this country. Although some very creditable work was reported, the need for some standardization is evident."

Request Blank for

NEW AND REVISED TENTATIVE SPECIFICATIONS AND TEST METHODS ISSUED SINCE JANUARY 1, 1946

The following nine specifications and eight methods of test have been accepted as tentative by the Society through the Administrative Committee on Standards since January 1, 1946. Members of the Society are entitled to a reprint copy of these new tentatives. A number of these are now available and others are being printed. Indicate on the blank below those specifications and methods that you would like to receive. The reprints will be sent you as soon as they are available.

Please Indicate Items Desired, Fill in Address, and Return Promptly to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

CHECK ITEM DESIRED	NEW OR REVISED TENTATIVES
	Steel Pipe
_____	Specifications for Seamless Chrome-Molybdenum Alloy-Steel Pipe for Service at High Temperatures (A 280 – 46 T).
	Electrical-Heating and Electrical-Resistance Alloys
_____	Method for Life Test of Electrical Contact Materials (B 182 – 46 T).
_____	Specifications for Nickel-Chromium-Iron Alloy Castings (35–15 Class) for High Temperatures (B 207 – 46 T).
	Copper and Copper Alloys
_____	Specifications for Copper-Nickel-Zinc Alloy Wire (B 206 – 46 T).
	Cement
_____	Specifications for Air-Entraining Portland Cement for Concrete Pavements (C 175 – 46 T).
_____	Method of Test for Air Content of Portland-Cement Mortar (C 185 – 46 T).
_____	Method of Test for Fineness of Portland Cement by the Air-Permeability Apparatus (C 204 – 46 T).
_____	Specifications for Portland-Blast Furnace Slag Cement (C 205 – 46 T).
_____	Method of Chemical Analysis for Darex Air-Entraining Agent in Portland Cement (to be incorporated in C 114 – 46 T).
	Rubber and Rubber-Like Materials
_____	Methods of Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids (D 471 – 46 T).
_____	Methods of Testing Cellular Rubber Products (D 552 – 46 T).
_____	Specifications for Insulated Wire and Cable: Heat-Resisting Synthetic Rubber Compound (D 754 – 46 T).
_____	Specifications for Insulated Wire and Cable: Performance Synthetic Rubber Compound (D 755 – 46 T).
_____	Specifications for Cellular Rubber Products (D 798 – 46 T).
_____	Method for Heat Aging of Vulcanized Natural or Synthetic Rubber by Test Tube Method (D 865 – 46 T).
_____	Specifications for GR-S Synthetic Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 866 – 46 T).
	Shipping Containers
_____	Method of Drum Test for Containers in Small Revolving Hexagonal Drum Box-Testing Machine (D 782 – 46 T).

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New Members to May 3, 1946

The following 100 members were elected from March 15 to May 3, 1946, making the total membership 5937:

Names are arranged alphabetically—company members first, then individuals.

Chicago District

DITTO, INCORPORATED, Robert H. Lace, Quality Control Manager, 2243 W. Harrison St., Chicago 12, Ill.

GRIFFITH, RALPH, Supervisor, Analytical Labs., Research and Development Dept., Sinclair Refining Co., East Chicago, Ind.

GUTZEIT, GREGOIRE, Director, Research and Testing Lab., General American Transportation Corp., 4405 Euclid Ave., East Chicago, Ind.

KERR, A. W., Consulting Engineer, A. W. Kerr and Associates, 407 S. Dearborn St., Chicago 5, Ill.

LAMB, GEORGE G., Professor of Chemical Engineering, Department of Chemical Engineering, Northwestern University, Evanston, Ill.

Cleveland District

NATIONAL SPECTROGRAPHIC LABORATORIES, INC., H. M. Bedell, President, 6300 Euclid Ave., Cleveland 3, Ohio.

WILLIAMS, W. R., Assistant Chief Metallurgist, The Youngstown Sheet and Tube Co., Youngstown 1, Ohio.

Detroit District

KAISER-FRAZER CORP., Roger F. Mather, Chief Metallurgist, Metallurgical Dept. 761, Willow Run, Mich.

DETROIT, CITY OF, PUBLIC LIGHTING COMMISSION, A. M. Lorenz, Electrical Engineer, 174 E. Atwater St., Detroit 26, Mich.

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PARTINGTON, SYDNEY, Chemist, The Detroit Testing Laboratory, 554 Bagley Ave., Detroit 26, Mich.

New York District

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DEERING, MILLIKEN AND CO., INC., W. R. Kuenzel, Director of Fabric Development, 240 Church St., New York 13, N. Y.

GENERAL PRECISION LABORATORY, INC., R. L. Garman, Technical Director of Research, 63 Bedford Rd., Pleasantville, N. Y.

MAGUIRE INDUSTRIES, INC., H. B. Harding, Director of Quality and Standards, 1437 Railroad Ave., Bridgeport, Conn.

RUBBER AND ASBESTOS CORP., A. X. Schmidt, Technical Director, 26 Cornelison Ave., Jersey City, N. J.

TICKLE ENGINEERING WORKS, INC., ARTHUR, Archibald Watt, Metallurgist, 21 Delevan St., Brooklyn 31, N. Y.

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FEIST, HERBERT, Production Engineer, Universal Camera Corp., New York, N. Y. For mail: 15 Delavan St., New Brunswick, N. J.

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GOULDEN, HAROLD D., Director of Scientific Research and Standards, 9 Rockefeller Plaza, New York 20, N. Y.

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METZ, D. A., Manager, Technical Service, Zapon Division, Atlas Powder Co., Stamford, Conn.

O'DETTE, STANLEY RAYMOND, Engineer, Standard Oil Co. (N. J.), 30 Rockefeller Plaza, New York, N. Y. For mail: 1422 Martine Ave., Plainfield, N. J.

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SITZER, PHILIP, Chief Engineer, Special Product Div., Tung-Sol Lamp Works, Inc., 95 Eighth Ave., Newark 4, N. J.

Northern California District

SHELL OIL CO., INC., C. C. Wuth, Standards Engineer, 100 Bush St., San Francisco 6, Calif.

Philadelphia District

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CATALYTIC ENGINEERING AND CONSTRUCTION CO., H. J. Monnik, Chief Engineer, 1608 Walnut St., Philadelphia 3, Pa.

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SMITH, HARRY F., JR., Technologist, Philadelphia Quartermaster Depot, 2800 S. Twentieth St., Philadelphia 45, Pa. For mail: Bethlehem Pike and Valley Green Rd., Whitemarsh, Pa.

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THIERRY, JOSEPH A., 2760 Stephens St., Palmer Heights, Easton, Pa.

TRIPLETT, STANLEY D., Materials Engineer, Pennsylvania Department of Highways, 1118 State St., Harrisburg, Pa. For mail: Box 321, Ardmore, Pa.

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Pittsburgh District

PITTSBURGH CORNING CORP., John C. Kohl, Development Engineer, 632 Duquesne Way, Pittsburgh 22, Pa.

ALTER, GEORGE E., JR., Senior Fellow, Mellon Institute of Industrial Research, 4400 Fifth Ave., Pittsburgh 13, Pa.

HICKS, LAURENCE C., Associate Director of Research, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

QUAY, ALBERT HARRISON, Chief Inspector, Tube Div., Jones & Laughlin Steel Corp., Box 430, Aliquippa, Pa.

THATCHER, FREDERICK M., Superintendent of Coke Plant, In Charge of Technical Development and Chief Chemist, Carnegie-Illinois Steel Corp., Clairton, Pa.

WALKER, LESTER R., Chief Metallurgist, Edgar Thomson Works, Carnegie-Illinois Steel Corp. .Braddock, Pa.

Southern California District

MCCREERY, DON HULL, Vice-President, Quinton Engineers, Ltd., Suite 300, 816 S. Figueroa St., Los Angeles 14, Calif.

SPRINGER, LEE M., Engineer, Utility Industries, 403 S. Raymond, Pasadena 2, Calif. For mail: 3830 Grayburn Ave., Los Angeles 43, Calif.

Western New York-Ontario District

NIAGARA WIRE WEAVING CO., LTD., THE, Stanley S. Skupiewski, Niagara Falls, Ont., Canada.

CALLAN, PHILIP J., Materials Engineer, Eastman Kodak Co., Material Standards Dept., 343 State St., Rochester 4, N. Y.

CUMMINGS, LLOYD A., Chief Engineer, Marlin-Rockwell Corp., 402 Chandler St., Jamestown, N. Y.

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JOHNSTONE, EDWARD J., Lockport Felt Co., Newfane, N. Y. For mail: 372 High St., Lockport, N. Y.

MERMAGEN, HERBERT, Director, Industrial X-ray Lab., University of Rochester, Rochester 3, N. Y. For mail: 260 Crittenden Blvd., Rochester 3, N. Y.

NORRIS, C. E., Purchasing Agent, Purchasing and Stores Div., Treasury Dept., Corporation of the City of Toronto, 203 City Hall, Toronto 1, Ont., Canada.

U. S. and Possessions

ALMIN, LTD., David Basch, Representative in U.S.A., 203 N. Brandywine Ave., Schenectady 7, N. Y.

AMERICAN CONDITIONING HOUSE, INC., H. J. Wollner, President, 11 Melcher St., Boston 10, Mass.

DEERFIELD SAND CO., INC., J. S. Newlin, President and Treasurer, Ridgeland, S. C.

JACKSON IRON AND STEEL CO., THE, Wilfred H. White, Metallurgist, Jackson, Ohio.

MONARCH CEMENT CO., THE, Otto C. Hasse, Chief Chemist, Humboldt, Kans.

NEW DEPARTURE DIVISION, GENERAL MOTORS CORP., H. D. Stephens, Chief Metallurgist, Bristol, Conn.

SAMPSON TESTING LABORATORY, E. J. Sampson, Jr., Owner, 1919 N. W. Twentieth St., Oklahoma City 6, Okla.

SERVEL, INC., R. S. Taylor, Chief Engineer, Evansville, Ind.

VIRGINIA ELECTRIC AND POWER CO., F. W. Smith, Seventh and Franklin Sts., Richmond 9, Va.

BASILE, GEORGE I., Manager, Product Testing, International Business Machines Corp., Endicott, N. Y. For mail: 1611 Riverview Drive, Endicott, N. Y.

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CLAPP, NEWMAN B., Supervisor of Quality Control Labs., Westinghouse Electric Corp., Small Motor Div., Lima, Ohio.

ELETA, FERNANDO, 428 Memorial Drive, Cambridge, Mass. [J]

GARLOCK, NEIL B., Section Chief, Paint Research, The Eagle-Picher Co., C and Porter, Sts. Joplin, Mo.

GRANGER, ROBERT R., Metallurgist, Struthers Wells Corp., Titusville Forge Division, Titusville, Pa.

HATHAWAY, CLAUDE M., President and Chief Engineer, Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.

LUGER, K. E., Partner, K. E. Luger Co., 3618 Washington Ave., Houston 7, Tex.

MANNA, LOUIS, Director of Control, Joseph E. Seagram and Sons, Inc., Louisville 1, Ky. For mail: 1436 Larchmont Ave., Louisville 8, Ky.

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PATTERSON, E. W., Director, Southern Petroleum Laboratories, 5502 Lawndale, Houston, Tex.

RICHARDS, T. L., Sales Manager, Riehle Testing Machine Division, American Machine and Metals, Inc., East Moline, Ill.

SANDBERG, JOHN H., Chief Metallurgist, Emsco Derrick and Equipment Co., Box 1289, Houston 1, Tex.

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WOERNER, GELDARD H., Ensign, C.E.C., U.S.N.R., Assistant Civil Engineer, U. S. Navy. For mail: 3306 Cleveland, Kansas City 3, Mo. [J]

Other than U. S. Possessions

COMMONWEALTH PORTLAND CEMENT CO., LTD., THE, R. G. Milligan, Manager, Box 1571, Sydney, N. S. W., Australia.

DUNLOP RUBBER AUSTRALIA, LTD., R. R. Blackwood, Technical Manager, Normanby Rd., Montague, Victoria, Australia.

ENGELER, A., Director, Swiss Testing and Research Station, St. Gall, Switzerland.

FERNÁNDEZ-LADREDA, JOSÉ MARIA, Engineer and Secretary, Ministro de Obras Públicas, Madrid, Spain.

GROSCH, H., Chief Engineer, Norges Elektriske Materiellkontroll, Fuglehaug gt. 11, Oslo, Norway.

LABORATORIO DE LA ADMINISTRACIÓN NACIONAL DEL AGUA, Calle Charcas 1840, Buenos Aires, Argentina.

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MELVILL, FRANCIS LEOPOLD, Consulting Chemical Engineer, Anglo-Transvaal Consolidated Investment Co., Ltd., Anglovaal House, Fox St., Johannesburg, South Africa.

NEW SOUTH WALES, PUBLIC LIBRARY OF, John Metcalfe, Principal Librarian and Secretary, Macquarie St., Sydney, N. S. W., Australia.

SILL, JOSEPH, President, The National Testing Laboratories, Ltd., 223 James St., Winnipeg, Man., Canada.

TAIT, IRVING R., Chief Engineer, Canadian Industries, Ltd., Box 10, Montreal, P. Q., Canada.

* [J] Denotes Junior Member.

Personals . . .

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

NORMAN E. WOLDMAN, formerly Chief Metallurgical Engineer, Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J., has resigned from this position to establish his own company, the Woldman Engineering Laboratories, Newark, N. J.

BENJAMIN J. LAZAN has been appointed Associate Professor of Metallurgy and Director of the Materials Testing Laboratory in the College of Applied Science, Syracuse University, Syracuse, N. Y. He was formerly Vice-President and Chief Engineer, Sonntag Scientific Corp., Greenwich, Conn.

JESSE T. LITTLETON who was formerly Vice-President and Associate Director of Research with the Corning Glass Works, Corning, N. Y., is now Vice-President and Director of Research with the same company.

ELMER L. JOHNSON, General Partner, Concrete Conduit Co., Colton, Calif., was elected president of the American Concrete Pipe Association during its 38th Annual Convention in Chicago.

RUSSELL FRANKS has been appointed to the Technical Service and Development Dept., Electro Metallurgical Co., Pittsburgh, Pa. He was formerly Chief Metallurgist, Union Carbide and Carbon Research Laboratories, Inc., Niagara Falls, N. Y. Both of these companies are affiliates of Union Carbide and Carbon Corp.

FRED P. PETERS has been appointed Associate Publishing Director of the Reinhold Publishing Corp., New York, N. Y. In this position, he will continue to act as Editor-in-Chief of *Materials and Methods*.

CYRIL STANLEY SMITH, Head, Institute for the Study of Metals at University of Chicago, Chicago, Ill. (along with Enrico Fermi, Harold C. Urey, and Samuel K. Allison), has been presented with a U. S. Army Medal of Merit Citation for activity in the production of the atomic bomb.

The Institute of Metals Division Award of the A.I.M.E. for 1946 has been presented to P. W. BAKARIAN and C. H. MATHEWSON, Professor of Metallurgy, Hammond Lab., Sheffield Scientific School, Yale University, New Haven, Conn., for their interesting paper on "Slip and Twinning in Magnesium Single Crystals at Elevated Temperatures."

MARY C. WHITLOCK, formerly Assistant Professor of Home Economics, University of Illinois, Urbana, Ill., is now with the Bureau of Human Nutrition and Home Economics, Agriculture Research Center, Beltsville, Md.

VICTOR H. BRADFORD is now Vice-President and General Manager, Bennett Steel Treating Co., Newark, N. J. He was formerly Director of Chemical and Metallurgical Research, Walter Kidde and Co.

HERBERT S. LYON who was formerly Junior Administrator, Signal Corps, U. S. War Department, Belmar, N. J., is now engaged in estate analysis and conservation work.

C. E. REARDON who was Superintendent, Geneva Steel Co., Salt Lake City, Utah, is now Metallurgist, Carnegie-Illinois Steel Corp., Chicago, Ill.

L. A. BAUM, who was connected with the Johns-Manville Corp., Manville, N. J., as Research Chemist, is now Research Chemist, Socony-Vacuum Oil Co., Brooklyn, N. Y.

CARL RUHE has retired from his position of Chief Chemist and Metallurgist, Homestead Steel Works, Munhall, Pa.

CHARLES R. GENTRY has been released from active duty with the Navy and is now Junior Engineer, Reynolds Metals Co., Richmond, Va.

WILLIAM H. MILLS has returned from service in the Army and has re sumed his position as Testing Engineer, South Carolina State Highway Department, Columbia, S. C.

C. E. TOPPING, formerly Metallurgist, Hayes Industries, Inc., Jackson, Mich., is now Materials Engineer, Consumers Power Co., Jackson, Mich.

F. N. WRAY is now Engineer of Design, Highway Research Board, National Research Council, Washington, D. C. He was formerly Civil Engineer, Office of Chief of Engineers.

WILLIAM J. KOMMERS has been released from active duty with the Navy where he served as Chief Engineer, Executive Officer and Commanding Officer on an LST. He has returned to the U. S. Forest Products Laboratory in the Division of Timber Mechanics, Madison, Wis.

W. H. MILLER, formerly Assistant Acting Manager, Erie Bolt and Nut Co., Erie, Pa., is now General Manager of this company.

ARNOLD IVAN JOHNSON who has been serving in the Navy is now Junior Engineer, Nebraska Department of Roads and Irrigation, Testing Laboratory, Lincoln, Nebr.

W. L. HESS who was formerly Production Manager, Midwest Plastics Products Co., Chicago Heights, Ill., is now Co-owner and Chief Engineer, Anestite Co., Chicago, Ill.

WILLIAM S. HOUSEL has returned from service as Lieutenant Commander, U. S. Naval Reserve, Bureau of Yards and Docks, San Francisco, Calif., and has resumed his former connection on the faculty, with the Department of Civil Engineering, University of Michigan, Ann Arbor, Mich.

C. J. HOGUE, in Charge of Technical Service of the West Coast Lumbermen's Association in Seattle, Wash., who has represented the membership of this active group in the Society since 1919, recently retired although he intends to keep in touch with developments in his field and in this way will be cognizant of A.S.T.M. activity. Mr. Hogue has served on Committee D-7 on Wood for many years, representing not only the West Coast Lumbermen's Association but is also one of the A.R.E.A. representatives. He has taken a genuine interest in Society activities and on various occasions has assisted in connection with our work.

DONALD L. COLWELL on his return from an assignment abroad for the Army Air Forces, prior to which he was Coordinator of Conservation for the Navy Department, is now associated with The National Smelting Co., Cleveland, O. Mr. Colwell who is Chairman of A.S.T.M. Committee B-7 on Light Metals and Alloys, is making his headquarters in Chicago.

DEAN HARVEY, formerly Materials Engineer, Engineering Laboratories and Standards Department, Westinghouse Electric Corp., East Pittsburgh, Pa., retired from his active work with the com-

pany as of March 31. A Past-president of the Society and for a great many years active in its work, Mr. Harvey will continue his service on the Executive Committee. One of his very notable activities for A.S.T.M. was as the Chairman of Committee B-4 on Electrical-Heating and Resistance Alloys which he headed from the organization of the committee in 1925. Although he has relinquished this office, the committee has made him Honorary Chairman. He was also extremely active in the work of Committee D-13 on Textile Materials, heading its Papers Committee for some time and in Committee D-9 on Electrical Insulating Materials.

HERBERT H. HATCH has announced the 20th Anniversary of the Hatch Textile Research laboratory in New York City. Mr. Hatch began his textile career in 1908 with his father who was a textile expert.

Catalogs and Literature Received

LEEDS & NORTHRUP CO., 4934 Stenton Ave., Philadelphia 44, Pa. Catalog ED "Galvanometers and Dynamometers" describes and illustrates a comprehensive line of galvanometers for use in research, teaching, and testing. It includes complete specifications and prices for an extensive choice of d-c and a-c Galvanometers and Astatic Dynamometers. Lamp-and-scale and telescope and scale reading devices, shunts, damping coils, and other accessories and parts are also listed. Introductory material discusses galvanometer characteristics, selection of proper galvanometer, and use of moving-coil galvanometers. Illustrated. 37 pages.

W. H. AND L. D. BETZ, Philadelphia 24, Pa. A booklet 8½ by 11 in., entitled "The Consulting Division of W. H. and L. D. Betz." Explains the functions and method of operation of this consulting division. Included in the booklet are seven architectural flow diagrams chosen to present a cross-section of various types of problems encountered and how these problems were solved in each particular case. These diagrams embrace plants for softening water for industrial use, waste treatment, sewage disposal and pre-treatment of water for boiler purposes and others. 24 pages.

INDUSTRIAL INSTRUMENTS, INC., 17 Pollock Ave., Jersey City, N. J. A catalog entitled "Conductivity Cells" deals primarily with a wide selection of cells for checking various liquids under varying conditions. In addition to illustrating and describing each type, there is a ready reference chart whereby to select the cell in accordance with its constant and mechanical design.

FOSTER D. SNELL, INC., 305 Washington St., Brooklyn 1, N. Y. A small leaflet entitled "Microchemical Services" prepared to answer the question "What does a micro-analytical laboratory do?" 8 pages.

FLEISHER CHEMICAL CO., P. O. Box 616, Benjamin Franklin Station, Washington 4, D. C. This eight-page small folder describes the new indicator, Fleisher Methyl-Purple Indicator for replacing the methyl-orange indicator, so-called standard for all alkalinity determinations. Samples and literature sent to readers on request.

FISH-SCHURMAN CORP., 230 E. Forty-fifth St., New York 17, N. Y. Bulletin covering the Ubbelohde Viscosimeter, UV 297, which operates on the suspended level principle. Four pages. Also several other leaflets describing All-Purpose Inspection Lamp, Precision-Bore Glass Tubes, Optical Contour Comparator, and All-Glass Stirrer. All illustrated.

TINIUS OLSEN TESTING MACHINE CO., 550 N. Twelfth St., Philadelphia 23, Pa. Catalog 30 entitled "Olsen Universal Testing Machines" covering the company's entire line of Universal Testing Machines for tension, compression, and flexure testing. Included in this illustrated, 56-page catalog is a complete description of the principle and operation of the Olsen pendulum lever weighing system, hydraulic and electromechanical loading systems, testing ranges, and specification details on machines in ranges from 1000 to 1,000,000 or more pounds. Other sections are devoted to the "L" Type and Lo-Cap Universal Testing Machines, as well as the Olsen Electronic high-magnification recorder, proving rings, and accessory tools.

Society Appointments

Announcement is made of the following Society appointments:

V. J. ALTIERI, Eastern Gas and Fuel Associates, as representative of the Chemical Section of the American Gas Association on Committee D-16 on Industrial Aromatic Hydrocarbons, and also it is recommended on behalf of Committee D-16 that he be named as the Society's representative on the Chemical Section of the American Gas Association.

E. R. YOUNG, Climax Molybdenum Co., as representative of Committee A-3 on the Specification Study Committee of the A.F.A. Gray Iron Division.

A. A. JONES, Anaconda Wire and Cable Co., on A.S.A. Sectional Committee C-8 as representative of Committee B-1, succeeding G. E. ROLSTEN, Rome Cable Corp.

C. S. COLE, American Society for Testing Materials, as A.S.T.M. representative on A.S.A. Sectional Committee B32, replacing R. E. Hess. Mr. Cole will also serve as A.S.T.M. representative on the S.A.E. Non-Ferrous Metals Division, replacing P. J. SMITH.

C. L. WARWICK, American Society for Testing Materials, to serve on the Joint Committee on the Measurement of Opinion, Attitudes and Consumer Wants sponsored by the National Research Council and the Social Service Research Council.

R. P. MILLER, Consulting Engineer, reappointed on the A.S.A. Building Code Correlating Committee for a term of two years.

M. O. WITHEY, University of Wisconsin, appointed on the A.S.A. Sectional Committee A42 on Plastering, to succeed STANTON WALKER, National Sand and Gravel Association, resigned.

R. W. LAHEY, American Cyanamid Co., as A.S.T.M. representative on the T.A.P.P.I. Container Testing Committee.

H. C. MOUGEY, General Motors Corp.; J. D. RYAN, Libbey-Owens-Ford Glass Co.; and H. K. NASON, Monsanto Chemical Co., as representatives of the Society on A.S.A. Sectional Committee Z26 on Safety Glass.

NECROLOGY

(Dates of death are given where available)

JAMES W. HIGGINS, Packard Motor Car Co., Packard Motor Car Co., Detroit, Mich. (February 17, 1946.) Mr. Higgins served on Committee B-8 on Electrodeposited Metallic Coatings, where he was active in the work of Subcommittees I, II, III, IV, and V on Specifications and Definitions, Performance Tests, Conformance Tests, Electroplating Practice, and Supplementary Protective Finishes for Metallic Coatings.

H. J. KERR, The Babcock & Wilcox Co., Barberton, Ohio. (April 21, 1946.) Till ill health prevented his doing so in November, 1945, he served on Committee A-1 on Steel when he was especially active in the work of Subcommittees IX on Steel Tubing and Pipe, XI on Steel for Boilers and Pressure Vessels, XXV on Welding of Steel, and XXII on Valves, Fittings, Piping and Flanges for High-Temperature and Subatmospheric Temperature. He was also a member of the Research Committee on Effect of Temperature on the Properties of Metals of which he was Vice-Chairman, and he represented his company also on Committee A-10 on Iron-Chromium-Nickel and Related Alloys. Mr. Kerr represented Babcock & Wilcox Co. on the Joint Committee on Filler Metal from 1942 until 1945 when he was replaced by O. R. Carpenter, Babcock & Wilcox Co.

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